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PROCEEDINGS

OF

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

PITTSBURG, PA.

VOL. XII.

1896.

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ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

SIXTEENTH ANNUAL MEETING.

ALLEGHENY, PA., Jan. 16, 1896.

The sixteenth annual meeting of the Engineers' Society of Western Pennsylvania was held in the lecture room of the Carnegie Library Building, Allegheny, Pa., Thursday evening, Jan. 16, 1896.

President Johnson was in the chair.

The minutes of the last meeting were read and approved.

The reports of the following officers and committees were read and accepted:

REPORT OF THE TREASURER

For the year ending January 16, 1896.

1894. January 17.

Balance, ... $325 14

RECEIPTS.

Dues year ending Jan.,				1893	(2),	$ 14	00
"	"	"	"	1894	(4),	20	00
"	"	"	"	"	(10),	70	00
" ½	"	"	"	"	(1),	2	50
" ½	"	"	"	"	(1),	3	50
"	"	"	"	1895	(9),	45	00
"	"	"	"	"	(17),	119	00
"	"	"	"	1896	(47),	235	00
"	"	"	"	"	(226)	1,582	00
" ½	"	"	"	"	(1)	3	50
" ½	"	"	"	"	(1)	2	50
"	"	"	"	1897	(3)	21	00

On account, . . .	40 00	
Initiation fees, . . (20)	100 00	
Total from dues, . . .		$2,258 00
From sales of Proceedings, .		82 11
From Advertisements, . .		101 00
Refunded by Academy of Science and Arts and Associated societies for share in Janitor's wages,		52 75
Special contribution to Library,		3 00
Miscellaneous, ...		1 50
Total receipts and balance, .		$ 2,823 50

EXPENDITURES.

Printing and Binding, . .	$1,078 30	
Engraving and reproducing diagrams, ...	69 30	
Salary of Secretary's Assistant, .	600 00	
Office Expenses, . . .	175 42	
Periodicals, ...	88 35	
Care of rooms, . . .	116 00	
Stenographers, ...	70 25	
New books, . . .	23 80	
Insurance, ...	20 00	
Plumbing, ...	12 00	
Total, ...		$2,253 42
Balance, ...		570 08
		$2,823 50

Respectfully submitted,

A. E. Frost,
Treasurer.

Allegheny, Pa., January 16, 1896.

REPORT OF THE SECRETARY.

Mr. President and Members of the Engineers' Society of Western Pennsylvania:

Our membership at the date of the last Annual Meeting, January 17, 1895, was	430
There were admitted to membership during the year, 21, of these 20 matriculated, . . .	20
Making the total enrollment, ...	450
There were eighteen (18) resignations, two (2) deaths, and fifteen (15) names were dropped from the roll at the last Yearly Meeting, making a total of .	35
So that our present membership is, . .	415

At the Annual Meeting, after the election of officers to serve for the year was held, the various committees presented their reports and Mr. Chas. Davis, the retiring President, delivered his address.

The average attendance at the monthly meetings during the year was 34; the papers presented were upon various Engineering subjects, and interest in them well maintained, as the frequent animated discussions attest.

There has been a slight diminution over the previous year in the number of applications for membership, but fortunately a corresponding decrease is observed in the number of resignations. It is hoped, however, that considerable accessions to our list will ensue and increasing interest by members be manifested upon the removal to Pittsburg, of our quarters, to a more accessible location and into more commodious apartments.

The Board of Direction at its regular meeting in January last decided to discontinue the printing and binding of the Proceedings of the Society as an Annual Volume. The paging of the Monthly numbers, however, has been made consecutive, and a Title Page and Table of Contents will be provided and

mailed with the December issue which will contain, bound with the Transactions for that month, a corrected list of our members and a list of the officers and committees for 1895 and 1896, so that members may have their numbers bound into a volume uniformly with preceding ones.

Respectfully submitted,

DANIEL CARHART,

Secretary.

REPORT OF LIBRARY COMMITTEE.

The following books have been purchased by the Society during the year 1895:

Two volumes, "Roofs and Bridges." By Mansfield Merriman.

"A Treatise on Hydraulics." By the same author.

One volume, "Roofs and Bridges." By Mansfield Merriman and Henry S. Jacoby.

One volume, "The Strains in Framed Structures." By A. J. Du Bois.

The Society has received, during the year, from other organizations, twenty-six books and sixty-two periodicals; and there have been added to the Library by binding forty-three volumes.

F. C. PHILLIPS,

Chairman.

REPORT OF COMMITTEE ON ROOMS.

The Committee on Rooms would report: At the meeting one year ago to-night, the first step toward securing rooms in the business portion of Pittsburg was taken, by the meeting instructing the Board of Direction to report upon the advisability of such a course. At the meeting held June 20th, 1895, the Committee on Rooms was instructed to secure quarters for the Society in the business portion of Pittsburg for a term of three to five years, with a proviso in the lease for either the purchase

of said quarters, at a sum to be stated in the lease, or for a term of three to five years without provision of purchase. The annual expense for quarters shall not exceed $900. The action of the committee was to be subject to the approval of the Board of Direction, the latter being empowered to execute a satisfactory lease.

In pursuance of the above resolution the Board of Direction have leased the house 410 Penn Avenue for five years from April 1st, 1896, at an annual rental of $1,500. It is proposed to have the Society occupy the main portion of the second floor, one room of which is well suited for our meetings, being about 23x36 feet. It is estimated that the Society can easily sub-lease the balance of the house on such terms as will make the net rental less than $900. It will require quite a sum of money to fit the rooms up, but it is intended in the near future to ask for subscriptions to a fund for this purpose.

GEO. S. DAVISON, *Chairman*,
WALTER E. KOCH,
EMIL SWENSSON.

BOARD OF DIRECTION.

The Secretary presented the report of the Board of Direction, in which it was recommended that the names of certain delinquent members be stricken from the roll, and upon motion this recommendation was concurred in.

The Auditing Committee, of which Mr. G. W. Schlueder-berg was chairman, reported that the accounts of the Treasurer for the year ending December 31st, 1895, were correct, and the report was accepted.

The retiring President then read his address.

ADDRESS OF THOS. H. JOHNSON, THE RETIRING PRESIDENT.

Under a provision of the By-Laws it has been made the duty of the retiring President to deliver an address on surren-

dering the chair to his successor. History informs us that the immortal Washington, on retiring to private life, delivered a "Farewell Address" to the people who had honored him with the highest office in their gift. We thus have not only a mandatory requirement, but also the eminent authority of a most illustrious example for thus afflicting you to-night.

It has been said that "the proper study of mankind is man." So also the proper subject for an address of this character before a local Engineers' Society is the local engineering field by which we are surrounded and with which we are in touch, and our relations as a society to it and to each other.

Unfortunately for me my immediate predecessor treated you to an exhaustive resume of the engineering operations of this vicinity; and his predecessor gave you with equal fullness a review of the history of the Society from its inception, the work accomplished by it, and the principal achievements of many of its members.

In both these directions the ground has been so well covered that there seems to be nothing left for me but a brief allusion to the work of the past year—not exhaustively, but to carry forward some of the leading features of the address of one year ago.

The ship canal, for which our esteemed Past President, Col. T. P. Roberts, has labored so assiduously, has passed through the preliminary stage of agitation and talk, and has reached the stage of completed first survey, with results on paper, containing all the data necessary to determine the engineering problems involved, the feasibility of the project, and a definite estimate of cost. It now remains to organize the financial side of the scheme, preparatory to the serious undertaking of the work. I understand that steps have already been taken to secure charter-rights under the U. S. Government. As an aid in educating the public to the importance and feasibility of the project, a very fine topographical relief map of the region covered by the surveys, has been made and placed on exhibi-

tion, first in the Pittsburg Exposition, and now in the Museum at the new Carnegie Library in Pittsburg.

At the date of the last annual meeting the Twenty-second Street Bridge was still in embryo. To-day it stands practically completed, but not yet opened for traffic, an event which may be looked for in the near future. This structure grew out of the popular demand for free bridges, and to further meet that demand proceedings have been had to condemn the three existing bridges spanning the Monongahela. The values fixed by the viewers do not seem to be satisfactory to either party, and what the result may be is not yet apparent.

In modern Steel Frame Buildings, while Pittsburg shops have been busy for several years producing structures of this class for other cities, comparatively few have been erected within our midst. Of the tall many storied sky scrapers, we can only boast two, the Carnegie Office, completed, and the Park Building in progress. In other cities where buildings of this class are more numerous, we find a growing sentiment against them, and in favor of legal enactments to restrict their height. The objections urged against them are two-fold. First, the upper stories are beyond the reach of water in case of fire. Second, as such buildings multiply they shut out air and sunlight from the streets and lower stories, especially when the streets are narrow. This latter condition has a two-fold effect. It tends to create unsanitary conditions, and renders the lower stories undesirable for occupancy. The latter effect would in time work its own remedy, for owners would soon begin to offset the loss of rental in the lower floors against the gain from the upper floors. Also the cost of additional stories is not to be rated by the materials entering into the upper stories, but by that of the lower stories, which must be made stronger as the structure grows in height. In addition to the unsanitary conditions resulting from loss of air and sunlight, there is also a legal question as to the right of one individual to thus restrict his neighbor's right to God's free air and sun-

shine. The recognition of these objections is turning attention to a proper remedy. It has been suggested that the height of all buildings should be limited to a certain ratio of the width of the street on which it abuts, with a maximum limit fixed at the height to which the fire department can throw water. To the latter limitation it may be urged that these structures are fire-proof, and this restriction is unnecessary. But if only the contents of a single room are destroyed it may entail serious loss; and we all know that the best fire-proof construction is not an absolute, but only relative protection. Restricting the height of buildings within reach of the firemen would seem to be a wise measure.

Under the direction of the Joint Committee representing this Society, the Allegheny Medical Society and the Chamber of Commerce, the work of educating our people and city officials in the matter of pure water supply is still going forward. An experimental station has been established, where the efficiency of sand filtration as a means of removing bacteria, and preventing disease, is being fully tested in a most scientific manner.

Educational work in this direction was further advanced by the recent lecture of Dr. T. M. Drown, President of Lehigh University, under the auspices of this committee. These efforts are only seed sown. Whether they have fallen on good ground, on stony ground, or by the wayside to be consumed by the fowls of the air, remains to be seen. It is to be hoped that they may yet spring forth and bear fruit abundantly, and that our city officials may yet be brought to an appreciation of the fact that certain diseases are preventable, and their existence a crime. Then and then only may we hope to see our twin cities relieved of the stigma of being the most prolific hotbed of Typhoid Fever in the United States, if not in the civilized world. The work of this committee will no doubt be reported to you fully and in detail by the committee itself at a future time.

At one of our largest industrial works much thought and labor has been expended by a member of this Society in perfecting a so-called "Gas Dynamo." The object sought is to drive the dynamo by power obtained direct from a gas fuel, without the intervention of the steam boiler and engine with their attendant losses, which have been so ably set forth in the series of papers read before you during the past two years. This is a great step in the economical generation of electricity. The result is accomplished on the principle of the Otto engine, by the explosion of a mixture of gas and air, but in this case the explosion takes place in the cylinder of a rotary engine, whose shaft is continuous with that of the dynamo. We thus have both engine and dynamo in one machine, without belting, gearing or countershaft; in fact without any moving parts other than the main shaft and its attachments. In this respect it is novel and unique.

In matters of general interest outside of our immediate surroundings, I note that Melan concrete construction for floors of fire-proof buildings seems to be growing in favor. The use of the Melan system for large engineering works has not attained the same prominence in this country that it has in Europe. No doubt we will come to it in time when the experience of the more venturesome has convinced the conservative and the timid that its stability and durability may be relied upon. To reach that end both engineers and contractors must more fully realize that good, first-class concrete work cannot be done with sand on whose surface a film of dirt interposes between each grain of sand and the cement. To get the best results the sand must be as clean as your Sunday linen.

The use of this system for floor construction acquires a local interest from the fact that in one form, as used, the iron which reinforces it, is the work of a local company represented in the membership of this Society.

During the past year a new competitor has entered the field of illuminants in the form of acetaline gas, made by the

reactions of carbide of calcium in water. This gas makes a wonderfully brilliant light, but I am not aware that it is as yet being supplied on a commercial basis. Certainly not in this city or vicinity.

Ærial navigation has not advanced to success during the past year, but I believe the work of experimental research for the controlling principle is still going on, and we know not what the future may have in store for us.

The last two topics, acetaline gas and ærial navigation, illustrate in a marked degree the widely different methods by which great achievements are sometimes accomplished. In the former case, failure to obtain a desired result led to disappointment, and in a fit of petulence a worthless mass is tossed into a vessel of water, and, *presto!* a great discovery. In the other case, careful, painstaking experiments have been made on fixed lines, and with a definite object in view, advancing step by step, meeting and removing obstacles as they are encountered, just as an exploring engineer cuts his pathway through a tangled forest. While Prof. Langley has not yet reached his objective point at the farther side of the forest, so far as he has penetrated his pathway is clean-cut and well-defined. Whether his efforts are ultimately crowned with success and he enables us to chase the wild-goose in his flight; or whether he finds that nature has set limits to restrain man's *soaring* ambition, we cannot fail to admire his masterly and scientific method of attacking the problem.

Just here I would like to say a word to our younger members. They must not expect to be made rich, or great, or famous by a single throw of fortune's dice, like that which gave us acetaline gas. Irritation and petulance are not usual factors in success. For most of us the only avenue by which to reach that goal is patient, persevèring, hard work.

We turn now to the Society itself.

When the great George made his famous farewell address he was not content with a simple "Good-Bye." He seasoned

it with some sound and sensible advice. We feel constrained to follow his example—"in our weak way and manner."

The Charter of our Society says "the object of this corporation shall be the advancement of Engineering in its several branches, the professional improvement of its members, and the encouragement of social intercourse among its members." Here we have three distinct lines of action in which this Society may expend its energies and justify its existence. The first and second are closely interwoven and interdependent. Whatever we as a society may do to advance Engineering must necessarily result in the professional improvement of our members individually. On the other hand, as our members grow in professional knowledge and ability it redounds to the glory of the profession.

For carrying out these two charter provisions, we hold regular meetings, at which we listen to papers on Engineering topics, and discuss the same. If the paper, or its discussion, reveals new facts, or discloses new principles, it literally fulfills the first condition by adding to the sum of our knowledge. If new facts are presented which strengthen and confirm old principles, or if old facts are presented in such way as to show up old principles in a new and stronger light, we are also contributing to the "advancement of engineering."

But it is not to be expected that every paper will thus lift our science to a higher plane, and it is to the second requirement that we must turn for our chief field of professional usefulness. Knowledge, like money, is not evenly distributed. No one person possesses all the scientific knowledge extant. Every one knows something which some other one does not know. Unlike money, knowledge may be given away and the giver's stock, like the widow's cruse, be undiminished. Each one can afford to give all that he has and not be impoverished, while the recipients will be enriched. Therefore, when a paper is under discussion let every one contribute his mite, no matter how seemingly insignificant it may be. Little things often turn

the scale and rule great destinies, and momentous principles are often revealed in the most trivial phenomena. If it is not a question of knowledge, but a difference of opinion; come forward and air that opinion, so that by exchange of views we may not only brighten our ideas and broaden our minds, but give life to our transactions

To the younger members especially I wish to speak on this point, and urge them to lay aside their timidity and diffidence, and take part in the discussions. If you do not feel equal to saying something instructive you can at least ask a question, and make some one else furnish the instruction. The sound of your own voice is the worst thing you have to dread. But it is not like the roaring of a lion, and once you become accustomed to hearing it, when on your feet, you will soon pass from the questioning to the talking stage.

But we cannot carry on a discussion without something to discuss. It has always been a source of complaint from the Program Committee that they found great difficulty in getting members to undertake the writing of papers. This should not be. While we know that Engineers as a rule are busy men, every one can find time to write a paper on some subject within the range of his knowledge, and about which others know less. If lack of confidence prompts him to re-enforce that knowledge by special study and research so much the better. The society will be the gainer, while at the same time the author's mind will have been enriched by his own labor.

The papers of the past two years show what can be done by a series of papers on kindred subjects, forming a connected whole. Members may be induced to undertake a special topic in such a series when it is shown to them that without their aid the sequence will be broken.

Good papers on live topics may also be obtained through the medium of special committees to investigate and report on given subjects where each member may follow out a separate branch and the individual efforts be subsequently united in a

completed whole, thus covering a broader field than could well be done by any one of them acting alone.

The third object prescribed by the charter, "the encouragement of social intercourse," has not received the attention that it should. We come together once a month, on the evening of the regular meeting, and for a short time while the members are assembling, friend talks to friend, but there is little or no general commingling and extending of acquaintance. The primary object in coming together is to follow a set form of procedure under parliamentary rules and listen to a learned discourse. The slight sociability developed is, we may say, accidental, and not the purpose of the meeting. The only intentional and premeditated social functions of the Society hitherto, have consisted of an occasional banquet in winter or excursion in summer.

What the Society needs is a series of stated meetings, alternating with the regular meetings, which shall be free from the restraint of parliamentary control, where sociability is the prime object of the gathering, and which may be made profitable by devoting a part of the evening to an informal, "*conversazione*" on some previously selected topic.

In addition to this, when we are once settled in quarters of our own, the rooms of the Society should be made a place of resort for members at all seasonable times. We should encourage this use of the rooms, and with that end in view every member should make a point of spending as many evenings there as may be consistent with other duties and engagements.

In conclusion I tender you my sincere thanks for the honor of presiding over your meetings during the past year, and for your uniform courtesy which has made that duty a pleasure.

January 16th, 1896.

The election of officers to serve during the ensuing year being in order, the President appointed Mr. Emil Swensson and

Mr. James M. Camp to act as tellers, who, after collecting and counting the ballots, reported that the candidates nominated by the Committee on Nomination of Officers had received all the votes cast, and the President therefore declared the following ticket unanimously elected:

President: W. G. Wilkins;
Vice President: (Two years) George S. Davison;
Directors: (Two years) W. A. Bole, Frans Engstrom;
Secretary: Daniel Carhart;
Treasurer: A. E. Frost.

The President-elect was then escorted to the chair and briefly addressed the Society, thanking them for the honor conferred upon him.

There being no further business, the Annual Meeting adjourned.

DANIEL CARHART,
Secretary.

January 16, 1896.

The regular monthly meeting of the Society was then held. President W. G. Wilkins in the chair.

The minutes of the last regular meeting were read and approved.

The Secretary read the names of eight applicants for membership, passed by the Board and to be voted on at the next meeting.

The following applicants for membership were unanimously elected by ballot: Thomas Fawcus, Charles Fitzgerald, Christen Mathisen and Edwin K. Morse.

Mr. L. B. Stillwell presented a communication from Mr. Philip Price Barton, being a discussion of the paper presented at the December, 1895, meeting. The communication was read and ordered printed.

Mr. H. W. Fisher moved that a committee of three be

appointed to collect data as to the cost of electric and steam-power plants, and report to the Society at some future date. The motion was seconded and carried. The President appointed the following members to serve on this committee: Messrs. H. W. Fisher, L. B. Stillwell and W. A. Bole.

On motion, duly seconded, the President appointed a committee consisting of Mr. H. J. Lewis and Mr. George S. Davison to prepare a memorial on the death of Mr. Hepburn Walker.

Mr. Davison moved that a committee of three be appointed for the purpose of revising the By-Laws of the Society. The motion was seconded by Mr. E. Swensson and carried. The President appointed the following members to serve on this committee: Messrs. George S. Davison, Emil Swensson and James M. Camp.

Adjourned at 10 P. M.

DANIEL CARHART,
Secretary.

CHEMICAL SECTION—FOURTH ANNUAL MEETING.

ALLEGHENY, PA., Jan. 17th, 1896.

The Fourth Annual Meeting of the Chemical Section was held in the Lecture Room of the Carnegie Library Building, Allegheny, Friday evening, Jan. 17th, 1896.

Chairman J. M. Camp presided.

The minutes of the last annual meeting were read and approved.

The report of the Secretary was read and approved.

Secretary reports as follows:

Number of members at last report	76
" " " resigned or dropped	24
	52
Number of new members elected in 1895	4
Lost by death	0
Total membership to date	56
Number of meetings	10
" papers read	9
" addresses	1
Total attendance of members	121
Average " "	12
Visitors present during year	23

A. D. WILKINS,
Secretary C. S.

Prof. F. C. Phillips, for the Sanitation Commission, made a lengthy report, showing the work they had done, what they had gained, and what they hoped for.

Dr. K. F. Stahl, for the Board of Directors, reported that new quarters had been secured for the Society and would be ready for occupancy after April 1st.

Prof. F. C. Phillips, for the Committee on Methods, reported the progress which had been made during the year.

Mr. J. M. Camp then delivered an address complimenting

the Chemical Section of the Engineers' Society on the work done, and suggesting points for future work; after which the Chemical Section elected the officers nominated for the ensuing year, as follows:

Chairman, J. M. Camp;
Vice Chairman, W. E. Garrigues;
Directors, Robert Linton, Dr. K. F. Stahl;
Secretary, A. G. McKenna.

Gentlemen: It is the honored custom for the retiring Chairman, on this the fatal evening on which he slips back to the ranks from the exalted state to which you have raised him, to deliver an address, wherein he gloats over the good that has been done, or mourns for that which "might have been," or lacking material here for his discourse, he may go away back of ancient history, and tell us a tale of the construction of the first Open Hearth Furnace, or spread before our wondering eyes a masterful discourse on Professional Ethics, or still better, find already written in the text-books a description of the Manufacture of Sulphuric Acid.

In November last I appointed a committee of those I thought my friends, who shamefully abused my trusting innocence, to nominate officers for the ensuing year. Forth they went into the world and returned with empty hands. So modest are all we chemists that not one deemed himself worthy to wear the mantle of the chairmanship. Back again like the dove from the Ark were they sent, but no olive branch did they bear indicating the presence of ground on which they could stand. So perforce, at personal sacrifice, I succeed myself as chairman of the Chemical Section. And without precedent in the course to pursue, I will make my address this evening as short as possible, thereby at least earning the gratitude of my hearers and possibly my successors.

On the whole we may congratulate ourselves on the past year's work, and the advent of this the new year will, I think, be the turning point for the better in our history. With our entry

into our new quarters in April, in the business part of Pittsburg, convenient to all the depots and street car lines, the attendance, and consequently the interest and value of our meetings must grow.

The ten papers read before the Chemical Section the past year were contributed by eight members, or about 12 per cent. of the total membership, leaving 88 per cent. who do not or but rarely attend our meetings, and who contribute nothing to our transactions or discussions. If these figures could be reversed, or why should we not all be active members? We then would have about seventy members present at our meetings instead of ten or twelve. And to what exalted heights then might we not climb. With your hearty co-operation it is my purpose after we are installed in our own quarters to establish a social evening to be given up to informal talk and mutual exchange of ideas. Saturday seems to be the favorite evening for these meetings with the week's labor done, and the 36-hour day—Sunday—following, in which to recover from the exhaustion following the discussions.

I thank you, gentlemen, for your kind attention during the evening, for your valued assistance the past year, and beg for its continuance during the present.

Annual meeting adjourned.

ALLEGHENY, PA., Jan. 17, 1896.

The regular monthly meeting of the Chemical Section was held after the adjournment of the Annual Meeting.

Mr. J. M. Camp was in the chair.

Ten members and six visitors were present.

Minutes of the last regular meeting were read and approved.

The Committee on Chemical Literature called attention to the following articles from Journal of Am. Chemical Society, Dec. 1895:

On the Estimation of Phosphoric Acid. C. B. Williams.

On the Estimation of Phosphoric Acid. B. W. Kilgore.

The Volumetric Estimation of Manganese. Geo. Anchy.

From Jour. Am. Chem. Society, Jan., 1896:

A Gravimetric Method of Estimating Phosphoric Acid as Ammonium Phosphomolybdate. Thos. S. Gladding.

From Am. Manufacturer, Jan. 10, 1896:

Physical Properties of Acetylene and of the Hydrate of Acetylene. M. P. Villard.

The chairman announced the following committees:

Sanitation: Prof. F. C. Phillips, W. E. Garrigues and Dr. K. F. Stahl.

Chemical Literature. E. S. Johnson, Dr. K. F. Stahl, G. Mueller, J. S. Unger and J. C. Barrett.

Methods. Prof. F. C. Phillips, A. G. McKenna and E. S. Johnson.

The paper on Some Properties of Acetylene was then read by Prof. F. C. Phillips. The paper was illustrated by various pieces of apparatus showing the generation of the gas from the calcium carbide, and peculiar properties of the flame using various kinds of burners.

ON SOME PROPERTIES OF ACETYLENE, BY FRANCIS C. PHILLIPS.

It is rare that a single organic compound occupies so large a share of attention in the journals and in the proceedings of scientific societies as has been accorded to the gaseous hydrocarbon acetylene.

Until a very recent period acetylene was known only in the text-books of organic chemistry, and its chief interest lay in the carbon compounds theoretically derivable from it. Now, however, the technical and commercial aspects mainly attract attention on account of the application which the newly-introduced gas is likely to find as an illuminant.

Preparation of Acetylene. Several methods have been proposed for its preparation :

1. When an alcoholic solution of potassium hydroxide is warmed with ethylene dibromide, acetylene is formed according to the reaction $2\ KOH+C_2H_4Br_2=2\ KBr+2\ H_2O+C_2H_2$. This process yields the gas in a very pure state, it being only necessary to use the potassium hydroxide in excess and to remove alcohol vapors from the product by means of a wash bottle containing broken ice.

2. It has been found that during the combustion of coal, gas in an insufficient air supply acetylene is formed in small quantity. Acetylene is, moreover, produced when a non-luminous gas flame plays closely against a cold iron surface, which retards combustion. On this account the odor of acetylene is often noticed about a gas cooking stove, especially where iron vessels are placed low down in the flame.

A method is described in Roscoe & Schorlemme's Treatise on Chemistry, Vol. I., p. 614, for the preparation of acetylene by the incomplete combustion of coal gas inside a Bunsen burner tube. The acetylene resulting is very impure, but may serve for the production of some of its more characteristic reactions. The escaping gas may be passed into an ammoniacal cuprous chloride solution, the resulting precipitate of the acetylene copper compound is then collected and washed and decomposed by hydrochloric acid. Acetylene in a purer state is then liberated. The admixture of air with the gas, due to the method of preparation in the Bunsen burner, interferes with the process by tending to convert cuprous into cupric chloride, and also by causing a different reaction to occur between acetylene and the copper salt, leading to the formation of a precipitate which is not easily soluble in hydrochloric acid, and consequently not so well suited to the production of acetylene.

Natural gas cannot be satisfactorily used as a substitute for coal gas for the formation of acetylene by this method.

3. Maquenne (Compt. Rend., 1892, p. 558) has de-

scribed a very excellent method for the preparation of acetylene from barium carbide. The barium carbide is made by heating a mixture of magnesium powder with barium carbonate and carbon. The experiment is best made in a piece of $\frac{3}{4}$ inch gas pipe about two feet long and capped at one end. The pipe, after receiving its charge, is placed upright in a coal stove. A reaction of a most violent kind occurs, some of the mixture being projected from the pipe. After the reaction is over, the pipe is quickly removed from the fire and cooled. An amorphous black mass of impure barium carbide is left. This material may be used for the preparation of acetylene by simply allowing water to drop upon it in a glass flask.

4. The recent method for the production of acetylene, by the action of water upon calcium carbide, has been found much more satisfactory, not only for commercial, but for scientific purposes, than any of the earlier methods. Calcium carbide produced electrolytically is purer than the barium carbide of Maquenne, and as it is a *fused* product, it is more easily preserved than the porous and easily oxidizable barium carbide produced by the method of Maquenne. The change which calcium carbide undergoes in contact with water is supposed to be represented by the equation :

$$CaC_2+2\ H_2O=Ca(OH)_2+C_2H_2.$$

As the calcium carbide may contain small quantities of sulphide and phosphide, the resulting gas is liable to be contaminated with hydrogen sulphide and phosphide; and as there is danger of ethylene and methane, and perhaps other gaseous compounds, it is best where pure acetylene is needed to absorb the impure gas in ammoniacal cuprous chloride solution.

The resulting red precipitate is, after washing, decomposed by hydrochloric acid, which liberates the acetylene in a very pure state.

Acetylene is a gas of very offensive smell. It is condensible to a liquid under 48 atmospheres pressure at freezing point.

Owing to its solubility in water it can not be stored over water without loss. For this reason it is probable that the gas will be preserved in liquified form in iron cylinders as in the case of carbon dioxide, nitrous oxide and ammonia.

Acetylene as an illuminant.—Preeminent among the qualities which characterize acetylene is the brilliancy of its flame. The following table illustrates in an interesting way the relationships as regards illuminating power of the three simplest hydrocarbons:

		Candle power when burnt at the rate of 5 cubic feet per hour.
Methane	CH_4	5
Ethylene	C_2H_4	68
Acetylene	C_2H_2	240

Unfortunately the high candle power of the flame when burnt from any ordinary form of burner is associated with the production of so much soot, that success in its introduction as an illuminant has been greatly impeded.

An acetylene flame is marked by another peculiarity which detracts somewhat from its usefulness for house illumination. The ignition of the gas is attended with a slight—but sharp—explosion, such as is noticeable in the case of hydrogen.

An argand burner produces a brilliant light, but the flame must be turned down to a height measuring a small fraction of an inch to avoid smoke. A seven-inch chimney seems to have little advantage over one of six inches. On lighting the acetylene as it escapes from the upper end of the chimney of an argand burner, an explosion of a somewhat violent kind occurs. This would in itself condemn the use of an argand burner for acetylene. The acetylene flame, when an ordinary 5-foot lava tip burner is used, presents a somewhat remarkable appearance. The inner non-luminous space is exceedingly small. This is surrounded by a brilliant yellow portion, while surrounding this above and at the sides is a dull red fringe, very smoky and emitting little light. The most luminous portion of the flame is therefore at the interior.

It has been found possible by means of a two-hole, flat-flame burner known as a Bray burner, which supplies an extremely small volume of gas per hour, to obtain a nearly smokeless flame, very brilliant and possessing the beautiful effects of a coal oil flame.

The inner blue space of this flame is contracted to about one-quarter of an inch in height and is sharply outlined. The entire upper portion is of a clear yellow color and emits a remarkably dazzling and beautiful light. Under a pressure of 1-inch or less of water the flame is slightly smoky, but under 1½-inch pressure the smokiness disappears, and at 2 inches pressure the flame is still brighter. At much higher pressures the flame begins again to produce smoke.

I have determined the illuminating power of acetylene using a Bray burner and have found that burning at the rate of 1.56 cubic foot per hour, acetylene produces a light equal to 64 sperm candles, or calculating the illuminating power for 5 cubic feet of acetylene per hour, 205 candles.

It is difficult to obtain data as to the cost of acetylene gas as all hinges upon the price of calcium carbide. Mr. T. L. Willson, President of the Willson Aluminium Company, who control the patents, has announced that calcium carbide may in the near future be sold for $15 or less per ton. One ton will make about 10,500 cubic feet of acetylene, having an illuminating power equal to about ten times that of an equal volume of coal gas. The price of calcium carbide as sold in New York at the present time is much higher than that announced by Mr. Willson. It would not be possible to estimate the cost of the acetylene light until more data are at hand.

The extreme steadiness of the acetylene flame would constitute a great advantage should this gas come into general use for house illumination. It is far less affected by draughts of air than a coal gas flame.

A Bunsen burner cannot easily be made to yield a non-luminous flame when dependence is placed upon the natural

draught. The gas produces a luminous and very smoky flame which tends to descend into the tube.

The very high temperature of the acetylene flame suggests that it might prove of use for the Welsbach burners.

The failure of the gas to burn satisfactorily from a Bunsen burner and the constant tendency of the flame to descend into the tube seem to preclude the probability that it can be used for this purpose.

Illuminating power of flames. One of the important results of the production of the new illuminant upon a large scale and at low cost has been to direct attention anew to the question of the cause of the luminosity of flames. Davy,* in 1818, suggested that the light of a gas flame is due to the setting free of carbon:

"In reflecting upon the two species of combustion I was led to imagine that the cause of the superiority of the light of the stream of coal gas might be owing to the decomposition of a part of the gas towards the interior of the flame where the air was in smallest quantity, and the deposition of solid charcoal, which, first by its ignition, and afterwards by its combustion, increased in a high degree the intensity of the light; a few experiments soon convinced me that this was the true solution of the problem."—Davy.

This view has been generally accepted and stated in the text books, but it is no longer a sufficient explanation of the facts. No attempt could be made here to discuss recent theories of flames, but it is proper to call attention to a paper by Vivian Lewed† upon the "Cause of Luminosity in the Flames of Hydrocarbon Gases." In this paper the following facts are presented:

Methane passed through a tube heated to about 1200° C, decomposes according to the equation :—

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*On the Safety Lamp for Miners, and Some Researches on Flame, p. 49.

† Light, Heat and Power, 1895, page 216.

$$2CH_4 = C_2H_2 + H_6,$$

while ethylene exposed to a temperature of 800° to 1000° may undergo the change :—

$$3C_2H_4 = 2C_2H_2 + 2CH_4.$$

When acetylene is heated to a very high temperature it decomposes into hydrogen and carbon, but at the temperature at which this decomposition occurs there is a sudden evolution of a large quantity of heat.

The production of heat attendant upon the dissociation of acetylene is easily understood when the thermochemical data are considered:—

(C,H_4)	=	+	18.5	Calories.
(C_2, H_4)	=	—	15.4	"
$(C_2, H_2,)$	=	—	61.1	"

Inasmuch as the union of carbon and hydrogen to form C_2H_2 causes an absorption of heat the dissociation of the compound will be accompanied by a disengagement of a corresponding number of heat units, and the liberated carbon floating in the flame will glow more intensely. With methane the action is of an opposite character, and in burning the carbon and hydrogen a certain quantity of heat must be rendered latent in overcoming their mutual affinity. This probably explains the difficulty encountered in attempting to produce a luminous flame from natural gas, which, when burnt from any but the regenerative forms of burners, emits so little light.

As regards temperature of dissociation, yield of acetylene and luminosity of flame, ethylene stands intermediate between methane and acetylene.

The luminosity of a flame, according to Lewes, depends then upon the quantity of acetylene produced in the lower part of a flame by the action of heat upon the hydrocarbons and its subsequent dissociation in the upper part of the flame.

The mere presence of carbon in a flame is not the chief cause of luminosity, as a flame may contain much carbon and yet emit very little light, but it is the production of acetylene by

decomposition of methane and ethylene into acetylene and hydrogen in the lower portion of the flame followed by the subsequent dissociation of acetylene in the upper portion which causes the light.

Acetylene for Blast Lamps.—The high temperature of the acetylene flame is likely to render it of value for use in blast lamps in the laboratory. A powerful blast of air is required to effect complete combustion and the results obtainable are decidedly more satisfactory than when the best coal gas is used.

In some experiments using an old-fashioned blast lamp and a foot bellows I have found it quite easy to soften and draw out hard glass combustion tubing of $\frac{7}{8}$-inch bore.

The flame is remarkably steady and the temperature is undoubtedly much higher than when coal gas or natural gas is used under the same conditions. A half gram of platinum foil, placed upon a block of lime, was easily melted in the acetylene blast lamp flame. Silver was melted and volatilized, coating a piece of lime with fine particles of the metal which had evaporated and condensed again.

The acetylene, as it was delivered to the blast lamp, was passed through a gas meter and all the effects above mentioned were easily produced in using the gas at the rate of one cubic foot per hour—(uncorrected).

Homologues of acetylene.—As calcium carhide has proved so valuable for the preparation of acetylene, it is a question of great interest whether the same substance could be utilized for the synthesis of the higher homologues of acetylene.

As the reaction $CaC_2+2H_2O=Ca(OH)_2+C_2H_2$ occurs so readily, it seems possible that by the use of methyl alcohol, methyl acetylene or allylene might be formed by such a reaction as the following:—

$$CaC_2+2CH_3OH=Ca\begin{cases} OH \\ OCH_3 \end{cases} + CHCCH_3$$

No such results occur, however.

In using methyl, ethyl, isopropyl, and isobutyl alcohols, acetylene is produced, although the action is much slower and other more complex reactions probably occur at the same time. Calcium carbide is very slowly attacked by chlorine, which liberates carbon.

According to Moissan, it is not altered by contact at high temperatures with hydrogen, nitrogen, silicon, sodium, magnesium, or tin. It burns slowly in oxygen, and becomes incandescent in sulphur vapor, yielding calcium sulphide and carbon disulphide.

Maquenne (Compt. Rend., 1892, p. 558,) found that it is not attacked by phosphorus pentachloride, acid chlorides or anhydrides. Concentrated nitric and sulphuric acids attack it very slowly. Dilute acids resemble water in evolving acetylene. So far as it has been studied it appears, therefore, that the change to which the calcium of calcium carbide is most prone is that by which it becomes calcium hydroxide, or slacked lime, and the formation of acetylene is dependent upon this reaction.

It is still an extremely interesting question whether experiments in the direction of the formation of the higher acetylenes will lead to satisfactory results. Aluminium carbide, Al_4C_3, produced electrolytically, yields methane on moistening with water, according to the reaction:—

$$Al_4C_3 \times 12H_2O = 3CH_4 \times 2Al_2(OH)_6.$$

Cast iron in contact with acids yields a variety of hydrocarbons.

Perhaps other metallic carbides may yet be produced which will serve for the preparation of higher hydrocarbons of definite composition.

Meeting adjourned at 10 P. M.

A. D. Wilkins,
Secretary C. S.

Engineers' Society of Western Pennsylvania.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

Allegheny, Pa., February 20th, 1896.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania, was held in the lecture room of the Carnegie Library building, Allegheny, Pa., Thursday evening, February 20th, 1896. Meeting called to order at 8.40, Vice-President Emil Swensson in the chair, forty-two members and visitors being present.

The minutes of the meeting held January 16th were read and approved.

Reporting for the Board of Direction the Secretary presented the names of nine applicants which had been approved for membership.

The Society then proceeded to the election of the following gentlemen to membership, Messrs. W. A. Bole and Franz Engstrom acting as tellers, and twenty-five votes being cast:

Herman A. Strauss,
John S. Unger,
G. C. Langenheim,
David L. Fulton,
Victor Beutner,
C. S. Brown,
J. C. Stulen.

Mr. Swensson then stated that about $100 had been added to the amount which is being raised to furnish the new quarters of the Society. He also stated that the subscription lists would be out within a week or so and that this would give the members an opportunity to increase the amount already subscribed.

Mr. Edwin Ruud then read a paper on "The History and Development of the Gas Engine," which was illustrated by lantern-slides.

THE HISTORY OF THE GAS ENGINE AND ITS DEVELOPMENT.

When I was asked to read a paper before you on the subject of gas engines, my first thought was to treat the modern engine, but as this paper is, as far as I know, the first presented to you on this topic, I thought by making this an historical one it would give many of the members a better idea and understanding of this important subject, and any future paper on this topic which the author or any of the members may give will be better understood and appreciated. As the gas engine stands to-day it forms a special and not very well-known branch in the mechanical engineering, and it is, therefore, not to be expected that every engineer should be entirely familiar with the modern gas engine and its workings, and if I can with this paper do anything towards enlightening the average engineer and bringing to his attention the great possibilities and future of the gas engine, my efforts will be rewarded. I have gathered much of my information from the works of R. Schöttler, D. Clerk and Gustav Chauveau, and I consequently feel indebted to the above authors.

On October 31st, 1791, John Barber received a British patent, No. 1833 (1), for "using inflammable air for the purpose of promoting motion."

Coal, wood, oil or any other combustible matter is placed in a retort ; the smoke or vapors are collected and cooled in a receiver. It is thence conveyed by an air pump to a compressor or regulating bellows which supplied it to an exploder. Common air is admitted by similar means in due proportion through another pipe, and the mixed air being ignited on application of a match or candle, rush out in a continued stream of fire, which works the engine, and which may be applied to every mechanical operation, etc. This is the first proposal we

(1) See Repertory of Arts, Vol. 8, page 371.

know of to utilize the explosive force of gases in an engine, although Barber's idea is vague, when we compare it with the developed gas engine of to-day.

Robert Street was granted a patent May 7th, 1794, British patent No. 1983 (2), "A method of producing an inflammable force by means of liquid air, fire and flame for communicating motion to engines, pumps, and machinery." The machine for effecting the foregoing objects consists of "an iron cylinder, a solid iron piston made to fit the cylinder, a strong frame in which the cylinder is suspended, a stove to keep the bottom of the cylinder hot, a counter-sunk touch-hole near the bottom of the cylinder. As soon as the bottom is heated sufficiently, pour a small quantity of spirits of tar or turpentine into the funnel, which falls on the hot part of the cylinder, and instantly the liquid is converted into an inflammable gas or vapor. At the same time raise the piston by means of the lever, which sucks in the air and also raises a light to the touch-hole. The confined vapor takes fire similar to gunpowder, and by the combined power of the inflammable and rarefied air thus incorporated, forces the piston up the frame and also raises with it the long shaft, which descends with the piston to the bottom and works the pumps or the machinery.

A certain Frenchman, "Lebon," took out a patent in 1801 (3). He described a gas engine having two pumps, one for air and one for gas to press the gases into an extension of the double-acting cylinder, where the mixture is exploded and acts on the piston. For ignition he proposes an electric spark, produced by an electric machine, which is driven by the engine itself. You will in this invention recognize the very principle of our modern engine, and had this Lebon had the facilities which we have to-day, and the courage to do some experimenting, there is no reason why he should not have brought out something practical. Even the electric igniter must be laid to his credit; he

(2) See Repertory of Arts, Vol. 1, page 154.

(3) Description des Machines et Procedes, No. 356, Vol. 5, page 123.

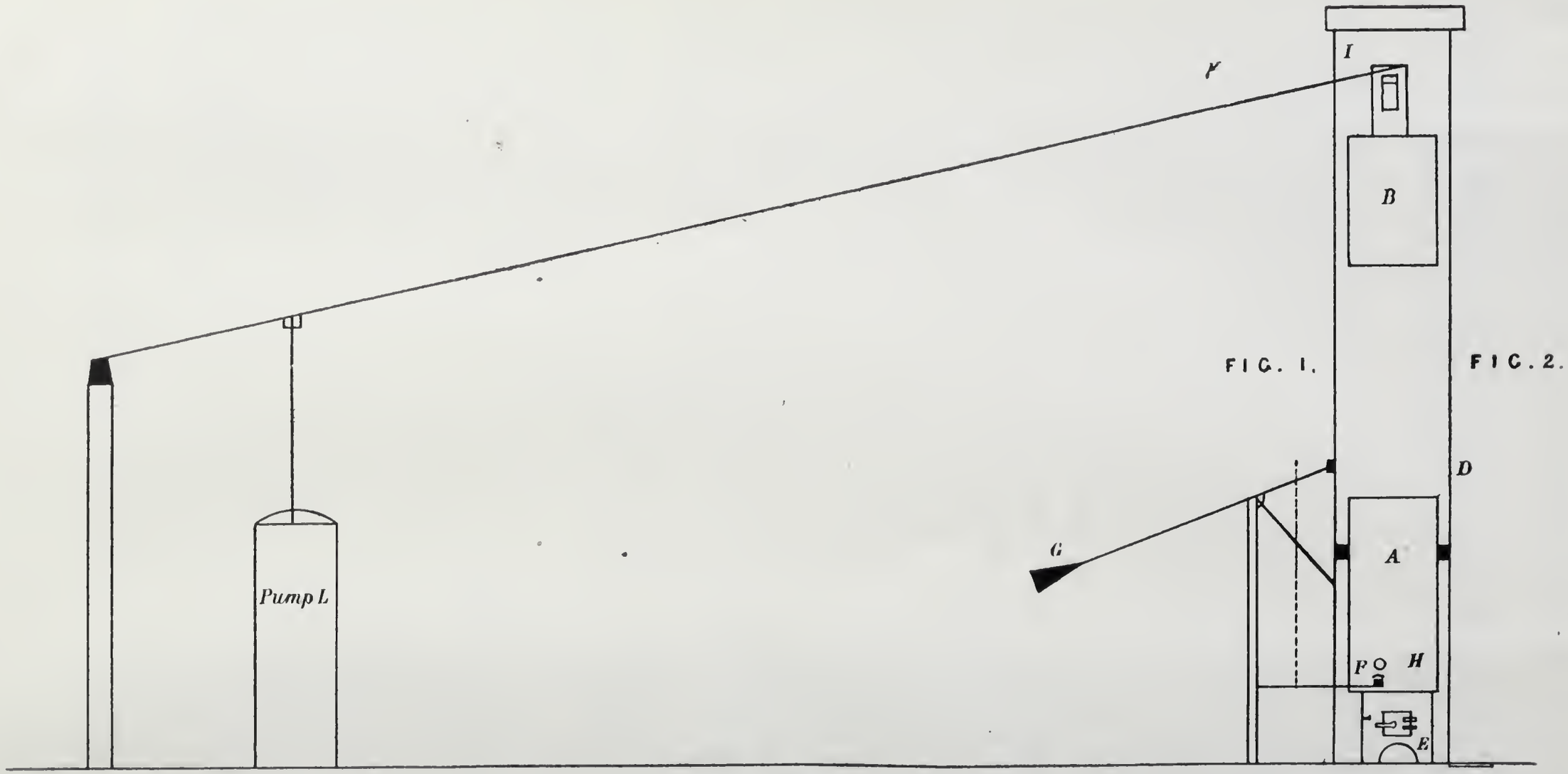


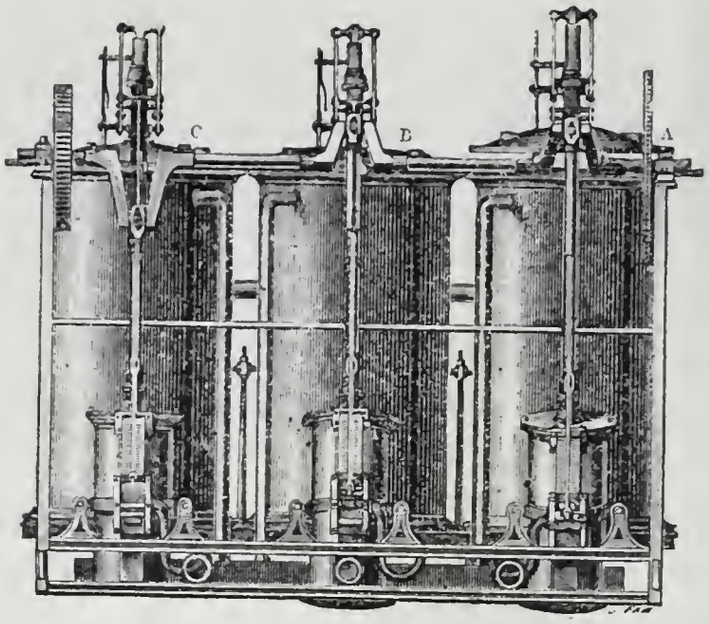
Fig. 2.
From Street's Specification.

is, as far as I know, the first one to propose the same. In one sense he may be regarded as the real inventor of the gas engine; on the other hand, he did nothing practical ; and after all it is the one who puts his invention or idea into a practical form that deserves the most credit. It is easy to talk about what may be done or what can be done, but to do it is quite another thing. Anyone who has any experience in the line of perfecting things and inventions will coincide with me. I regret that I have not been able to illustrate on the screen this and the two patents just described. While I was in Washington some time ago I ordered these old patents for this purpose, but they are difficult to obtain, and it has taken a longer time than was calculated on, as they had to be copied specially.

On Dec. 4, 1823, and April 25, 1826, Samuel Brown took out patents for improvements in gas engines. This engine may be called a gas-vacuum engine, as its power is obtained by vacuum, produced by a flame partially expelling the air, and a cooling is effected by introducing a water jet, causing a partial vacuum.

Brown's invention is interesting, but it has no practical value, as the pressure obtainable could never be more than a certain fraction of that of the atmosphere, besides not being economical. He seems, however, to have built and installed a complete plant (according to *Mechanics' Magazine*, published in London) in a boat which was run upon the Thames as an experiment. It is also stated that this Brown modified his machine so as to adapt it to a road carriage, which ran in London. Fig. 4 shows a full view of this Brown "gas-vacuum engine."

Every now and then a patent was granted on gas engines, but I shall pass by them until we come to the mention of Lemuel William Wright patent[4], Dec. 16, 1833, British patent No. 6525. From the picture you will see that it is a double-acting engine, the piston receiving two impulses for every revolution. Two pumps are employed to supply the explosive mixture, and the charge is exploded on the dead



A, Cover raised, vessel filling with flame. B and C, Covers down, vessels vacuous.

Fig. 4—Brown's Gas-Vacuum Engine, 1826.

centre by the use of a touch-hole, over which moves a slide, and provided with an external flame. The machine also has a governor, and the cylinder is water-jacketed; even the piston rod is made hollow and filled with circulating water. This is the first intimation we have of this important feature in a gas engine, and I should say that Wright must have built his engine, to judge from his knowledge of many practical touches about the machine.

Fig. 5 shows this engine in sections.

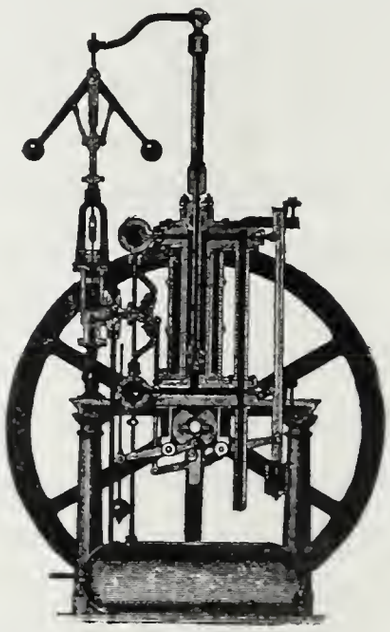


Fig. 5—Wright's Gas-Exploding Engine, 1833.

(4) See London Journal (Newtons') Vol. 5 pp. 137, Rolls Chapel Reports 7th Report, pp. 148.

I mention William Barnett's patent of 1838, April 18th, No. 7615, merely because he is to be regarded as the original inventor of the flame igniter, so extensively used once, and even to-day by many makers of gas engines.

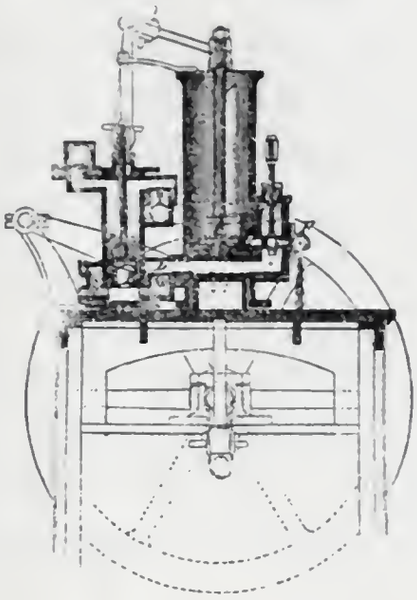


Fig. 6—Barnett Gas Engine.

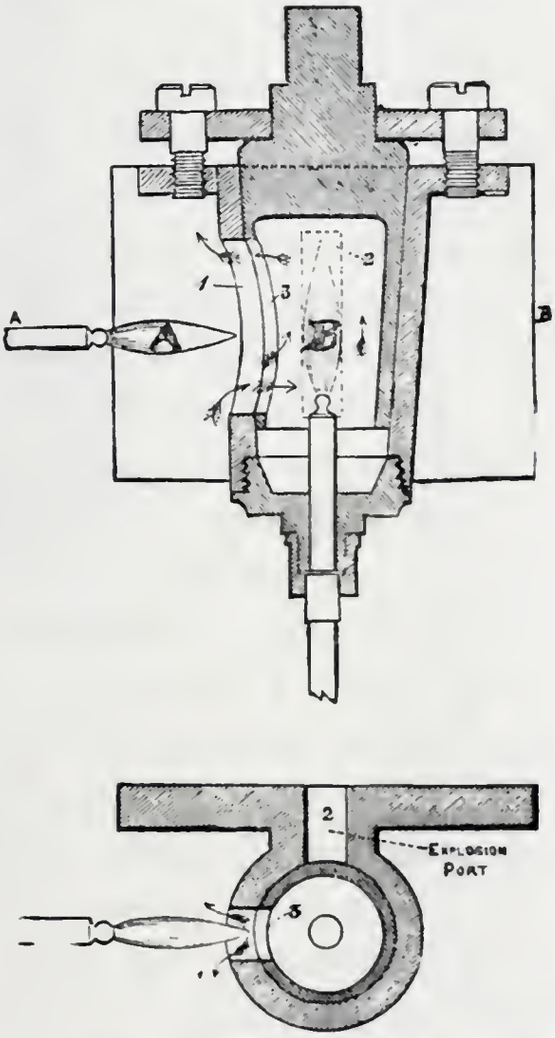


Fig. 7—Barnett's Igniting Valve (flame).

Fig. 6 shows his gas engine. Fig. 7 Barnett's flame ignition device, in which 2 communicates with the cylinder, 3 is the plug, about the same as an angle cock, 1 is the hole through which the re-lighting is done, a flame, A, burns on the outside and B on the inside, when the plug stands in the position shown. If suddenly the plug is turned so that 3 meets 2 the inner flame will ignite the cylinder charge. When this is done the plug is again turned in the first position, and the inner flame is relighted by the outside flame. This is ingenious and works well in a modified form which was later adopted by most of the gas engine manufacturers at one time. It is contended by some that Barnett is the inventor of the compression system, but this does not seem to be well-founded in view of what Lebon, as I have just described, proposed and patented in that line 37 years earlier.

The next invention in order of importance is that of Barsanti and Matteucci, patented in France February 20, 1858. Fig. 8 will give you an idea of this peculiar and bold way of constructing an engine. The idea being to give the explosive force a free chance to expand down to the atmosphere. The piston gives up the work to the machine when it is going downward, due to the vacuum formed and its own weight. This engine was built with two similar cylinders, but my description and Figure apply to but one. A is the cylinder and B is the piston. The piston rod is provided with teeth which engage in a wheel C which is loose upon the main shaft D. To this wheel C is attached a pall and ratchet arrangement F and E as shown. Under the main piston is another piston G which serves to draw in the charge. This piston is coupled up to the shaft J which makes half as many revolutions as the engine, by the aid of the connecting rods. Starting with main piston in the lower position as shown, the piston G goes downward, draws in air through ports a b c until a communication is established between the gas supply through d f, and a little farther travel will close in the charge at which moment it is

Fig. 8.

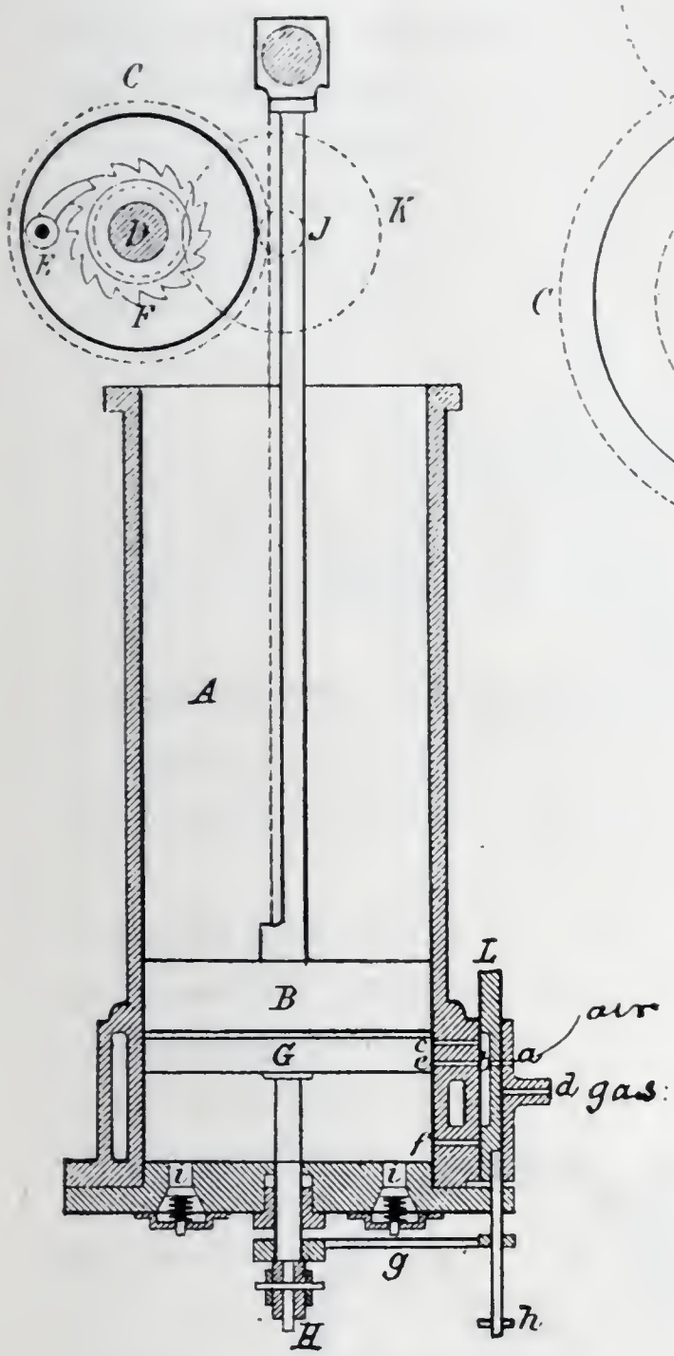
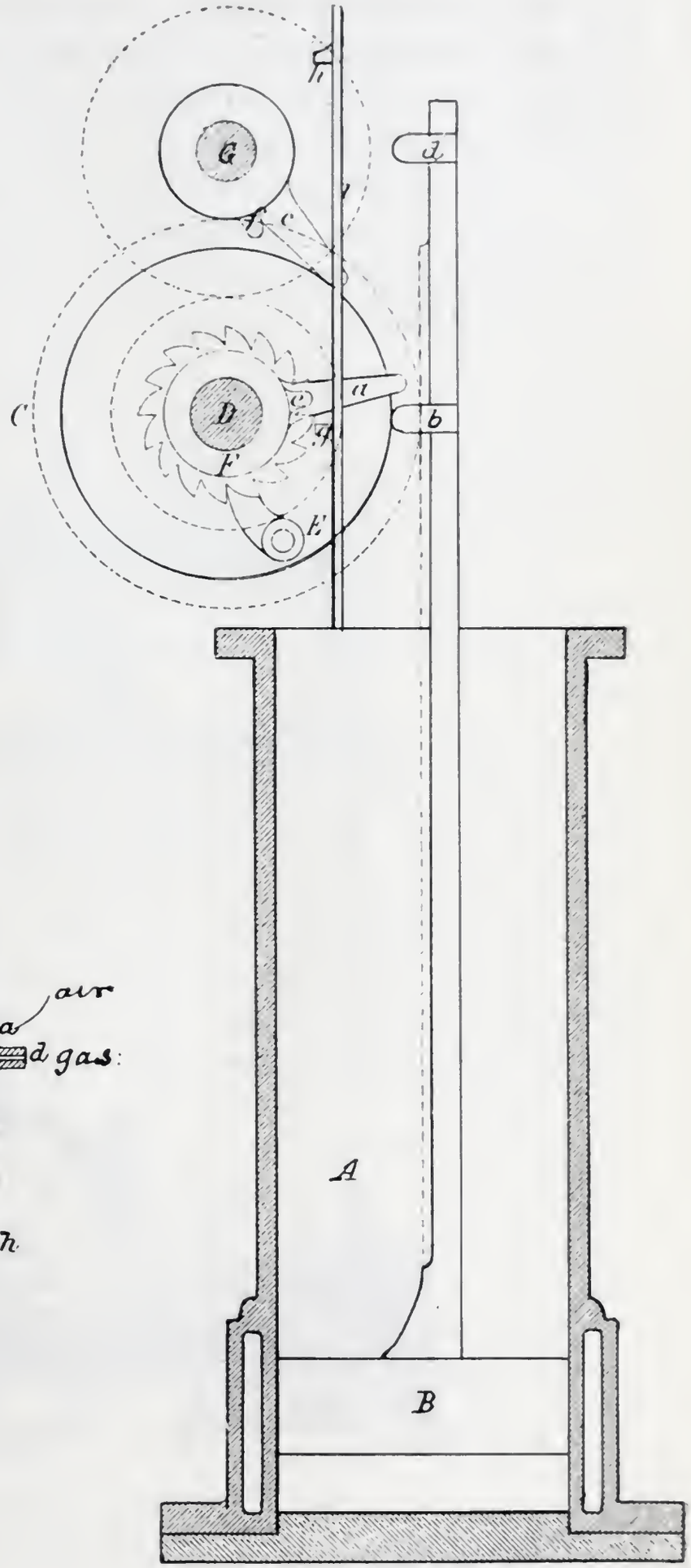


Fig. 9



ignited by an electric spark. The piston rushes upward lifting its own weight and overcoming the pressure of the atmosphere. A vacuum is then formed in the cylinder, the piston starts down and the ratchet takes hold and drives the engine shaft. The waste gases are expelled through e i, the slide valve stands in such a position as to form communication, as it is moved by the arm g, attached to the lower piston rod.

A variation in construction is shown in Fig. 9. Instead of the auxiliary piston the main piston is made to draw in its own charge by being lifted by the arm c taking hold of the projection d on the piston rod. The projection a serves to force the piston downward so as to expel the gases.

What a clumsy and unmechanical construction we have in this gas engine, and yet Otto and Langen came out with a similar machine in 1867, which found a ready sale, this we will see later.

To Jean Joseph Lenoir we must give the credit of having first brought the gas engine before the public in a practical shape, and although his engine was anticipated by several, he was the first to construct a commercial engine.

He put his engine on the market in Paris about the year 1860 and it created a sensation; people went wild over it and many were they who believed that this new power motor was destined to drive the steam engine to the wall.

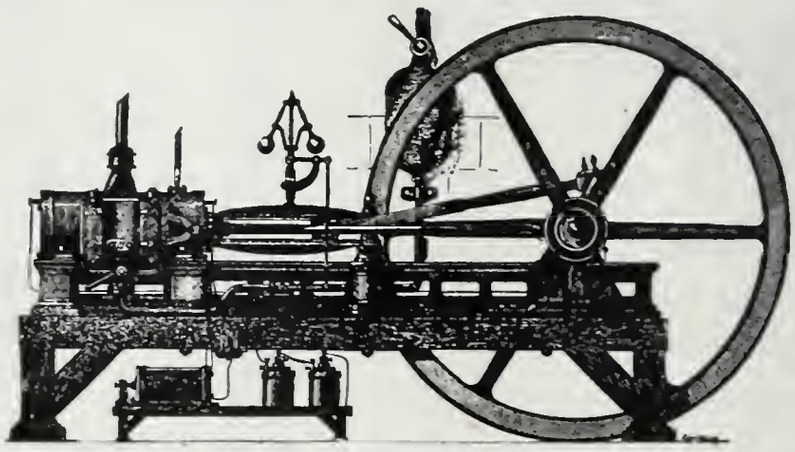


Fig. 10--Lenoir's gas Engine.

Fig. 10 shows a side view of the engine and Fig. 11 a

horizontal section of the cylinder. This engine gives two explosions for every revolution. This is accomplished by the piston drawing in the charge during the first half, or less, of its travel, and then firing it. The pressure rises suddenly and then falls off gradually, as the hot gases follow the piston through the remainder of the stroke; meanwhile the waste gases on the opposite side of the piston are being expelled. A water jacket surrounds the cylinder and the heads are also provided with water cooling.

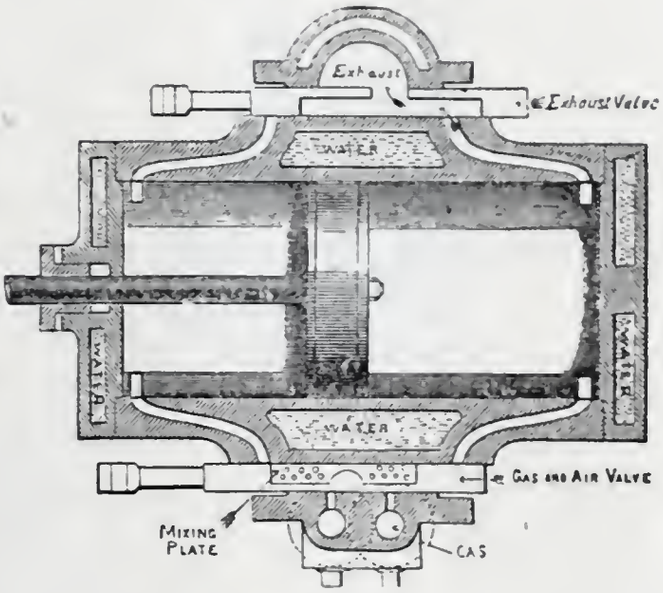


Fig. 11—Lenoir Engine, Cylinder (sectional plan.)

The card produced by this engine is shown in Fig. 12.[2] The card shows a partial vacuum in the cylinder at the time of the explosion, the maximum pressure varied from 5 to 7 at. and the pressure at the time of the exhaust, 1.5 to 1.8 at. The gas consumption is variously stated, but the average consumption of illuminating gas seems to have been close to 3 cu. M. per Brake H. P. per hour for small sizes. Tresca[1] made a test of a one-half H. P. Lenoir and found the efficiency to be 4 per cent. Another test was made by Slade on a two H. P. engine running at 50 R. per minute and the actual efficiency was 5.37 per cent.[2] The necessary water for cooling is said to be 120 L. per H. P. hour.

[1]Tresca in the *Ann. du Conrserv*, I., page 849.
[2]See Clerk, "The gas engine," page 128.

Notwithstanding this low efficiency of this gas engine it found a free introduction for awhile. It was only made in from one-half to three H. P.

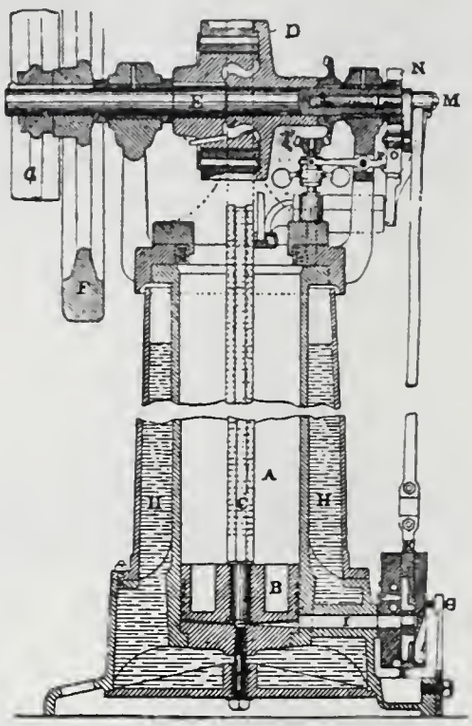


Fig. 13—Otto and Langen Engine (vertical section.)

The Lenoir engine was superceded by the Otto-Langen gas engine made by Otto and Langen of *Deutz*, which first came into notice at the exposition in Paris, 1867. Fig. 13 shows a vertical section of this gas engine. This engine was nothing more or less than the Barsanti–Matteucci engine, and the description of that engine will suffice for the Otto–Langen engine.

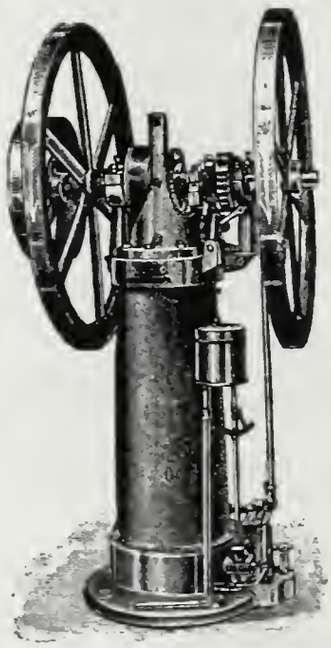


Fig. 14—Otto and Langen Free Piston Engine.

Fig. 14 gives an outline of this gas engine. Mr. Dougald Clerk made a test of a 2-H. P. engine working with Oldham coal gas. The number of ignitions being 28 per minute. Indicated H. P. 2.9, gas consumption per indicated H. P. 24.6, and the consumption per Brake H. P. 36 cu. feet per hour. Tresca made a test of a half H. P. engine at the exposition in Paris, 1867, and the gas consumption was at the rate of 44 cu. ft. per Brake H. P. per hour. According to Schöttler, the best results obtained was 0.8 cu. meter, that is 28.2 cu. ft. per H. P. per hour. Fig. 15 shows a diagram of an Otto–Langen. This engine held sway in the market for nearly ten years, and thousands of them were made and sold. The noise made by this engine is said to have been simply unbearable, but even that did not prevent its introduction, which was made possible by the great economy over the Lenoir engine which used about three times as much gas.

The same Otto who succeeded in producing a free piston gas engine, Patented in 1876 (British patent), a gas engine which proved to be so economical that the older forms of engines were at once driven from the market. It may be said that N. A. Otto was not the first to propose this type of engine, yet he was the first to build engines on, and demonstrate the great possibilities of his cycle (now called the Otto Cycle), and the first to do it without the aid of pumps and other accessories. The so-called "Otto Cycle" is as follows: The piston draws in the charge of gas and air like a pump during the first half of the revolution of the crank, then the charge is compressed during the second stroke and exploded on the head center. The rapid development of heat causes a tremendous rise in the pressure, and this acts on the piston during the third stroke, and at last the gases are expelled during the fourth stroke or second half revolution of the crank. Thus work is only done during a period of one-half revolution of the two revolutions of the crank, when one end of the piston is considered. Figs. 16 and 17 show an Otto eight horse power gas engine, such as was

made in 1879 or thereabout. (See Schöttler, Die gas machine, page 39). I have chosen the old type to show how closely it comes to the modern engines of the Otto type made by the different companies to-day in the different countries. A is the cylinder, B is the slide valve for the opening and shutting of the air and gas. D is the piston on whose end the pressure of the explosion acts which is transmitted to the crank in the ordinary way. E and F are gear wheels for driving the valves by the aid of the shaft G. H is a crank on the shaft "G" which drives the slide valve by the aid of the link J. K is the regulating valve for the gas.

This engine is provided with a so-called hit and miss device; that is, the governor places the cam P in such a position that the arm g will either be moved or stand still, and consequently the gas valve n will open up full or not at all.

The arrangement of the ignition is shown in Figs. 18, 19 and 20. A flame is burning on the outside of the machine in a chimney; this flame ignites the gas mixture formed in the valve at g, i furnishing fresh air; the gas enters through l and k while this mixture is burning, the valve moves until a communication is set up between the chamber g and the cylinder entrance "a" through k and m and a further travel brings g opposite a and the ignition follows. A device for taking off the compression is attained by the cam t being movable, and it may be placed in such a position by the lever v that it will move the exhaust valve C during the period of compression; this will facilitate the starting of the engine. The compression chamber of this engine is about two-thirds of the displacement of the piston and the compression about 3 at. absolute. The pressure in the cylinder at the time of the explosion is about 11 at. absolute and the exhaust valve opens somewhat before the end of the stroke.

According to a test made by Brauer & Schöttler, in Altona, March 9, 1881, a four horse-power Otto gas engine gave one horse-power actual per 912 L gas, revolutions 158.8 per M.

Another test was made by Dr. Slaby, of Berlin, on a four horse-power Otto engine at Otto's works, Deutz, May, 1881.

Diameter of Cylinder 171.9 millimetres.
Stroke 340 millimetres.
Compression space 4770 cu. centimetres.
Volume displaced by piston 7888 cu. C.
Average R. per min. 156.7.
Power ind. 5.04 h. p.
Power by dyn. 4 4 h. p.
Gas consumed per hour by igniting flames 2.75 cu. Ft. Gas consumption per 1 H. P. 28.3 cu. ft.

Gas consumption per B. H. P. 32.4.		
Work indicated in cylinders	16	per cent.
Heat lost to cylinder walls	51	"
Heat carried away by exhaust	31	"
Heat lost by radiation and conduction	2	"
	100.00	"

Temperature of exhaust gases 432° C.

Composition of the Deutz gas.

	volumes.	
CH_4	34.4	marsh gas.
C_2H_4	3 5	ethylene.
H_2	56.	hydrogen.
CO.	5.2	carbonic ox.

See Clark's Treatise on gas engine, page 172.

Let us now take a glance at some of the modern makes of gas engines, all of which employ the Otto Cycle.

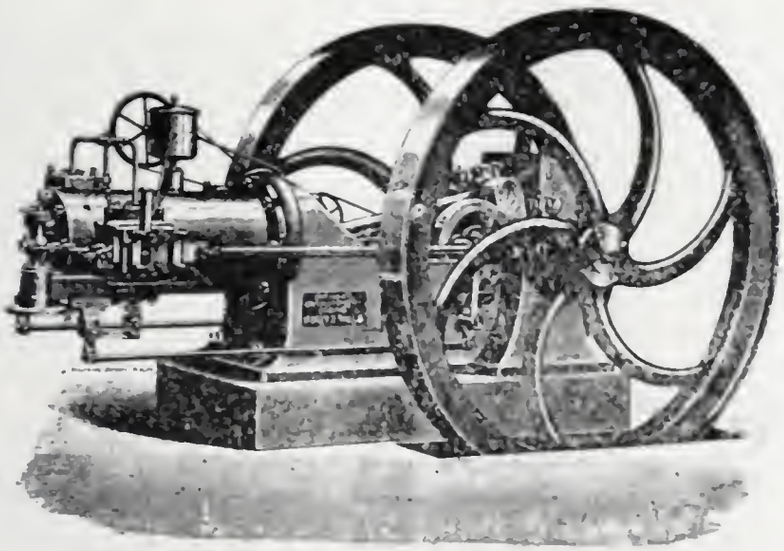


Fig. 24.

Fig. 24 shows a gas engine made by Dresdner Gas Motern Fabrick, and according to a test mentioned in their 1894 catalogue and made by Prof. B. Schöttler on a 12 H. P. engine the consumption of illuminating gas was 686 L per B. H. P. per hour. The gas consumption running empty 2980 L.

The American Otto is shown in Fig. 25 taken from the catalogue issued by the makers, Messrs. Schleicher, Schumm & Co. Many elaborate tests have been made of this engine, among which will be found one by H. N. Spangler in the Franklin Institute Journal, May, 1893. The consumption of combustible for a complete plant for a 100 H. P. two cylinder gas engine was 1.148 lbs. per B. H. P. per hour; this takes in the loss in the producer as well.

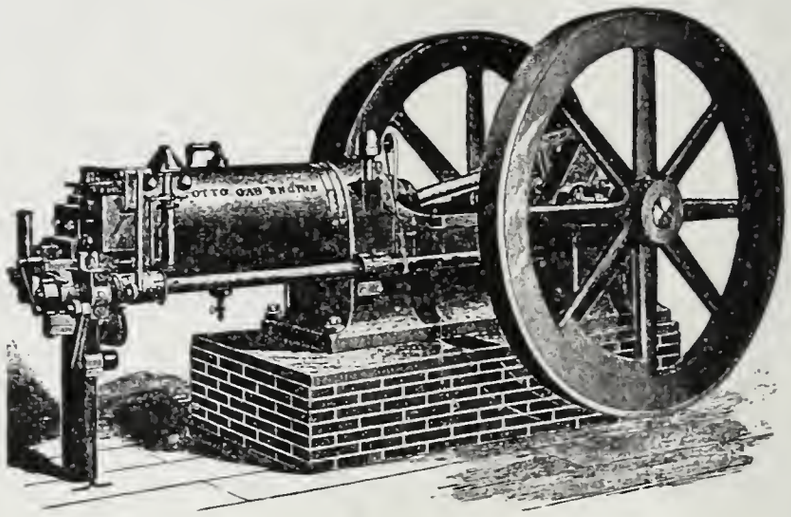


Fig. 25.

Fig. 26 shows a gas engine of a special type; it is double acting, just like the Lenoir gas engine, but it employs the Otto Cycle. Great difficulties have been experienced in trying to obtain one impulse for each stroke, as in a steam engine, and many ways and means, which would form a paper by itself, have been tried. For example: The use of pumps, the use of the other end of the piston, etc. This engine is made by Dick, Kerr & Co., England. I have had the opportunity of seeing two of their engines working, and they seem to perform their duty, and, as far as I could learn, the difficulties with the stuffing box, piston rod and the heating of the piston had been

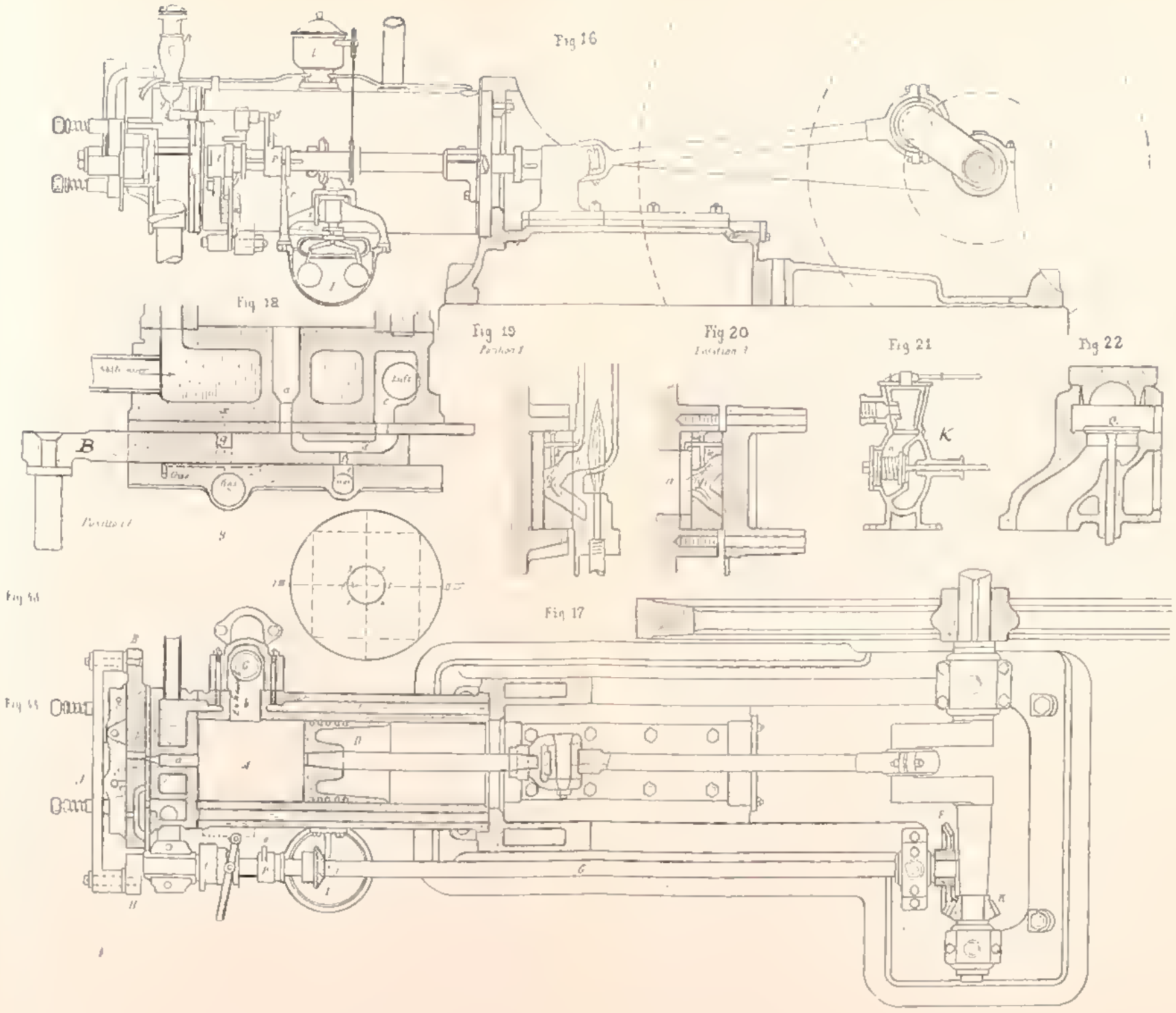


Fig 16
Fig 18
Fig 19
Fig 20
Fig 21
Fig 22
Fig 17
B
K

overcome. This firm calls attention to the fact that they set the ignitors so as to go off late, claiming a considerable gain thereby in actual work. As it looked very plausible, I thought I would try it, but found an actual loss in power instead of a gain by retarding the ignition.

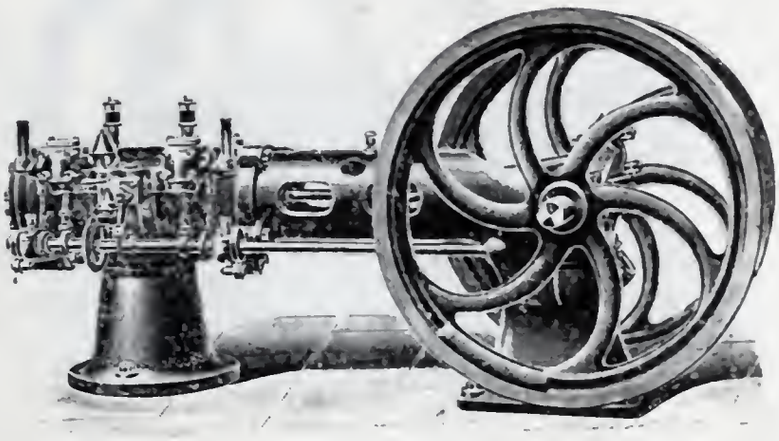


Fig. 26.

Fig. 27 shows a double-cylinder Otto gas engine made at Deutz. According to tests given in the firm's catalogue made by K. Teichman, professor Technichen Hockschule, in Stuttgart, April, 1892, a 25 H. P. gas engine gave one B. H. P. per 663 liter gas. Consumption, running empty, 6,200 liter per hour.

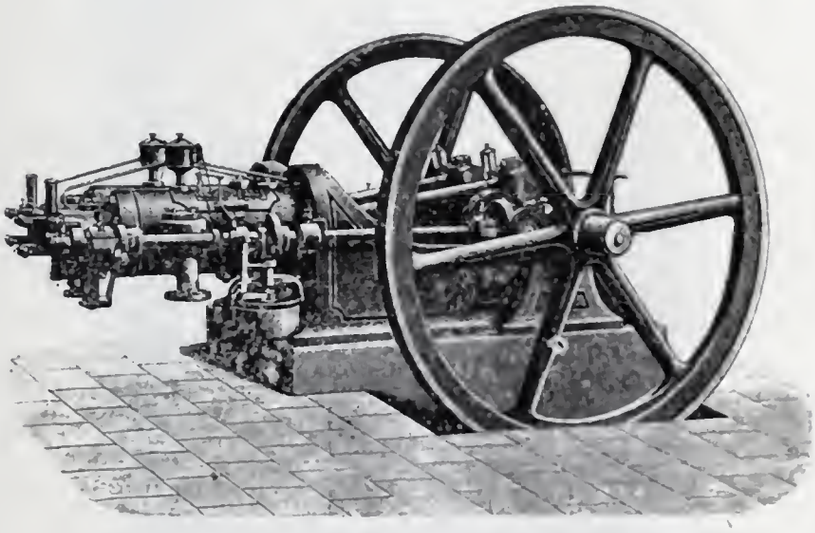


Fig. 27.

Fig. 28 shows another "Otto" made at Magdeburg-Buckau. This engine has not the ordinary centrifugal governor, but a lever with a movable weight, which performs the

regulation. I saw this engine working at the Chicago Exposition, and the speed regulation seemed to be fairly good, although not even enough for electric lighting.

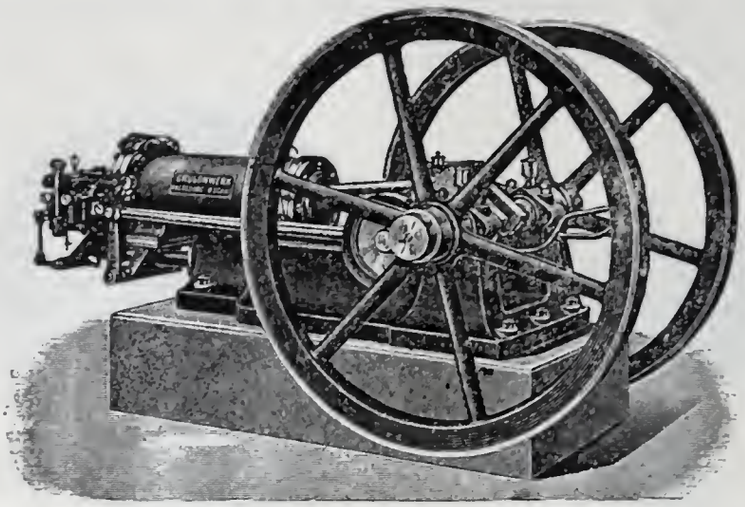


Fig. 28.

Fig. 29 gives an outline of a 5 H. P. Westinghouse gas engine. These engines are built especially for electric lighting, and have two cylinders, giving an impulse for every revolution. The regulation of these engines is as good as any first-class steam engine; in fact, so perfect that engines are now being

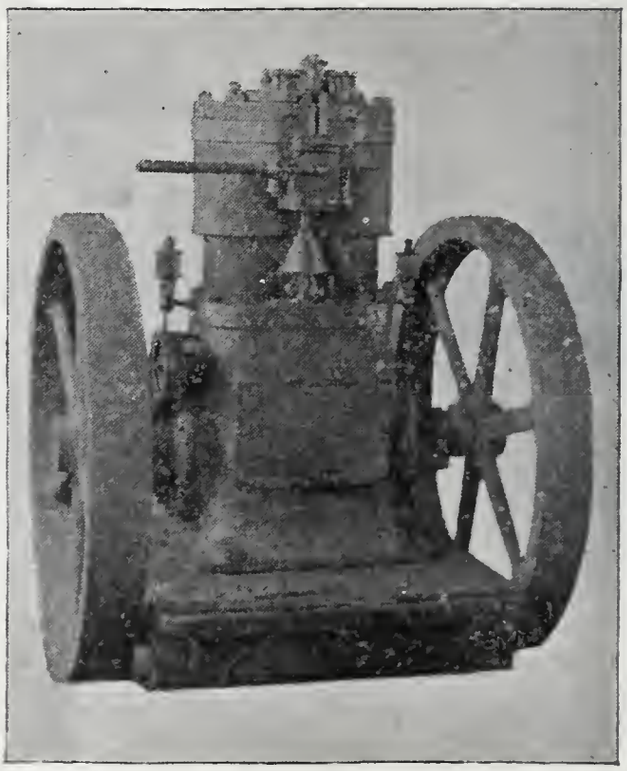


Fig. 29.

fitted up with the dynamo coupled directly to the crank shaft, thus making a compact and complete electric outfit, which does away with the belt, its noise and absorption of power. These engines can be run with illuminating gas, natural gas, producer gas or gasoline, and they are practically noiseless. The oiling is effected in the same manner as the well-known Westinghouse steam engine. According to tests made on an 18 H. P. engine, the consumption of natural gas per Brake H. P. was 16.7 cubic feet, the *load* being 21 B. H. P. I regret that I have not been able to get an analysis of the gas.

We have seen to-night how John Barber, towards the close of the last century, first conceived the idea of utilizing the explosive force of gas and air mixtures, and after this was done improvements followed by numerous inventors. We have seen how the Lenoir gas engine was crowded out by the free piston engine, and also how even this engine was forced to the wall by the invention of the Otto gas engine. My paper for to-night really closes with the creation of the "Otto." In some future paper I intend to take up the gas engine where I have left off, giving more detailed particulars and showing the gradual development of this prime mover. I also hope to be able to give you the results of some large and exhaustive experiments now being carried on by Mr. Westinghouse in the direction of further increasing the efficiency of the gas engine, especially for large units in connection with producers.

The gas engine of to-day occupies a different position from what it did a few years ago. It is now a practical machine, and there are but few purposes for which it cannot be practically adapted. The economy of the gas engine in comparison with the steam engine is so great that there can hardly be said to be any comparison bewteen them. The general introduction of these prime movers would be very beneficial to manufacturing and crowded communities, as it would eliminate the smoke nuisance, do away with accidents due to boiler explosions, and last but not least, would save millions of dollars in the way of

fuel. Great as has been the advancement of the gas engine in recent years, we may regard this as only a beginning, and we have every reason to believe that with the further introduction of this prime mover, its efficiency and usefulness will be greatly improved. I hope to live to see the day when the position of the steam and gas engine shall be reversed with regard to numbers. I also expect to see the great culm piles in the mining regions which now have no commercial value, transformed into gas by the aid of the producer and changed into electricity by the gas engine and dynamo, for the benefit of the large cities. I even expect to see the great transatlantic steamers propelled by this motor.

DISCUSSION.

THE CHAIRMAN—You have heard a fine discourse upon a subject more or less new to us, and I should like to hear a discussion of the subject. Has anyone any questions to ask?

MR. FISHER—I should like to know if it takes sixteen cubic feet per horse-power hour of illuminating gas, what it would take of natural gas?

MR. RUUD—I myself believe that the horse-power developed by the two gases for equal amounts would be in proportion to the heat units given off in combustion. However, the composition of the gas, as I have stated, would have some weight in that connection. The test would have to be made by trying both gases and comparing the results.

MR. FISHER—I have made a rough calculation and find at the rate of sixteen cubic feet, power would cost about $10 per horse-power per year at the present rate of charge for natural gas.

MR. RUUD—In an engine using 16 cubic feet of natural gas per horse-power per hour with gas at 22½c per 1,000 cubic feet, the fuel would not cost very much. In fact, the gas engine is especially adapted and very economical for electric lighting purposes.

PROF. FESSENDEN—For electric lighting purposes, the engines would be especially valuable, since the average load of a large central station is only about thirty-three per cent of the necessary maximum capacity of the plant. The stand-by losses and the other losses due to the fact that the engines can never be worked at their most economical point of load, are therefore very considerable. If Mr. Fisher's calculation be correct, this would reduce cost of power of production about one-half and the elimination of the other losses to which I have referred, would reduce the cost to not much more than one-fourth of the present expense of production.

MR. RUUD—The gas engine is especially adapted for electric stations as to saving, and there have been proposals made to use gas engines to deal with the peak of the load curve. I believe that the gas engine will find a speedy introduction into electric stations in the course of a comparatively short time. Regulation can be made as good as any first-class steam engine. It can be regulated to within one to one and a quarter per cent.

MR. FISHER—I believe I asked you the ratio between the cost of natural gas and illuminating gas. The cost of illuminating gas would be, I think, about fifty cents to one dollar per 1,000 feet. I would like to get an estimate of the cost in other cities where they do not have natural gas.

MR. RUUD—If you want to use illuminating gas, you would use it for small powers only. If you want to use an engine of large power, you would use producer gas, and you would find that it will cost just as much to fire a small power steam engine as a large power gas engine. Besides the illuminating gas companies are willing to give a discount for gas used for fuel purposes. In several cities they have the rate down to fifty cents.

THE CHAIRMAN—I take notice of several of Mr. Ruud's remarks in which he says something of the gas engine's superseding the steam engine. I should like to hear what Mr. Bole has to say about that.

Mr. Bole—I should not like to see the steam engine superseded entirely by anything, but if it has to be superseded at all, I am quite certain that it could not be superseded by anything more agreeable to me than Mr. Ruud's gas engine. I think that the gas engine is the most practical solution of the smoke question. As I have said before, the people whose smoke makes the greatest nuisance are not the people who use the greatest power, but who are locatedin places where a little smoke does the greatest damage. In order to run a steam engine it is necessary to have a steam boiler. Where a boiler is used in large plants, it is not such a dangerous affair, but any steam boiler at best is none too safe, and if it can be gotten rid of, so much the better for the lives of everyone concerned. I do not know whether it is proper to introduce the subject here, but I think that some action should be taken towards regulating the character of the steam boilers which are used in public buildings. I think that in buildings of this sort the danger to life would be diminished by the use of the gas engine. I feel that in great office buildings of the city, danger would be avoided if the gas engine could entirely supersede the steam boiler. It would also be a big item in doing away with smoke and dirt. Whether the exploded gas could be used for heating or not, I do not know, as I am not clear upon this subject. As to the matter of cost, that, in the case of small engine, would be moderate when compared with the cost of the steam boiler and engine, pipes and pumps. Also as to matter of attention. If the engine is of few horsepower, it is rarely necessary to have an engineer, and you would thus be able to reduce the item of wages. Anyone can light the flame and set the engine going.

A Member—I should like to ask at what point the explosion should take place in order to get the best results?

Mr. Ruud—I have found that the best results have been obtained by exploding the gas at the dead centre, just as the piston comes to a stand-still and the compression is greatest.

This point will vary, you will find by experiment, in accordance with the composition of the gas and the rapidity with which it is fired.

MR. MCGARY—Would you have the same control of that as you have of the steam engine?

MR. RUUD—Yes, you would have the same control. You can set the igniters at any point. You would frequently have to do this in the case of starting some engines. There is a firm in Baltimore who makes an adjustable igniter.

MR MCGARY—Then, is it to follow about the same line as the steam card?

MR. RUUD—Yes, sir.

MR. HIRSCH—In those gas engines where the hit-and-miss appliance is used, and where the wheel is carried over by its momentum, I should like to ask if the gas is changed. What is the case in the Westinghouse engine?

MR. RUUD—In the hit-and-miss device, the gas is not changed at all. You take in a full charge of gas and air, or no gas at all. The regulation of the Westinghouse engine is effected by increasing or decreasing the charge in accordance with the variations of the load, without disturbing the proportions of gas and air.

MR. HIRSCH—I should like to ask as to the different gases, what is the comparison between natural gas and ordinary illuminating gas?

MR. RUUD—The average of illuminating gas varies from 650 to 700 B.T.U. The natural gas varies from 900 to 1,000. I should think that about 950 would be an average.

MR. MCDONALD—In comparison with the steam engine, I should like to know the cost of the water in a steam engine of 25 horse-power and a gas engine of the same capacity.

MR. RUUD—The use of water depends entirely upon the purchaser. If you would order a larger engine, the use of water would be greater. The amount of water per horse-power per hour is about four gallons. You have the power to go

even lower than that by letting the water out at a higher temperature. With a circulating system there is no waste of water.

Mr. Bole—What is the percentage of clearance in the gas engine, and what is the temperature of the escaping gases?

Mr. Ruud—The percentage of clearance is from 15 to 20 per cent. The temperature of the escaping gases of an eight or ten horse-power engine would be about 400 C.

The Chairman—That would be good for heating purposes.

Mr. Bole—I wanted to know how much of that heat could be used for warming a building.

Mr. Ruud—The temperature in the cylinder varies from about 2,000 to 3,000 C. The amount of the exhausted gases per horse-power hour when you know the consumption of gas per hour is from nine and a half to ten times the amount of air when natural gas is used. This could be used in heating buildings. In fact, we shall soon have an engine finished adapted for house heating.

Prof. Stewart—The waste heat from the gas engine can be utilized for heating purposes about as readily as that from a steam engine. This can be accomplished in a hot water system by passing the water from the main return through the engine jacket, then through a special heater designed to absorb the available heat of the exhaust gases while on its way to the principal heater.

I would like to ask Mr. Ruud if he has any data relating to the completeness of combustion at the instant of attainment of maximum pressure in the Westinghouse engine?

Mr. Ruud—You mean at what point of the stroke the combustion is complete?

Prof. Stewart—It is well known that owing to dissociation or "after burning," the combustion is not complete when inflammation is complete. I use inflammation here in the sense in which Clerk has used it, namely, the spreading of the flame

throughout the combustible mixture. It would appear from certain results gotten by exploding gases in a closed vessel that combustion would be only about one-half completed upon the attainment of the maximum pressure in the modern gas engine. I assume that maximum pressure and complete inflammation will each be attained in the same time after ignition.

Mr. Ruud—That is well taken. At a high temperature it is supposed to be so, but different authorities disagree on this point.

Prof. Stewart—It is well known that if a mixture of hydrogen and oxygen in proportions to produce water be exploded in a closed vessel, the maximum temperature attained does not exceed one-third of what should be attained, supposing that combustion were complete and the resulting heat contained in the products of combustion. The combustion is not complete at the completion of inflammation that is at the attainment of maximum pressure, and would not be so, until sufficient heat were withdrawn to permit of its completion.

Mr. Ruud—From what I can see of the curve, it is a continuous falling line, showing that the combustion is very nearly complete at the very moment of ignition, if the mixture is perfect.

Prof. Stewart—An analysis of the indicator cards of a number of the modern gas engines igniting at constant volume has shown that the expansion line falls less rapidly than would be the case were heat not added to the gases during the completion of the stroke. Taking this in conjunction with the fact that the maximum pressure attained at or near the beginning of the stroke is only about one-half what should be attained were combustion complete at that instant, it would appear that combustion is complete only at some point late in the stroke.

Prof. Fessenden—Any disassociation effects would show up on the indicator card. It is found that such effects are actually present, and that they give rise to the inflections on the indicator diagram very much in the manner required by

theory. The results of some tests which show this were recently published, if I remember rightly, in the proceedings of the Physical Society of London.

Mr. Ruud—The inflections in the curve might be due to the inertia of the movable parts of the indicator.

Prof. Fessenden—That could not be so in this case, as the results were checked by means of a thermo couple inserted in the cylinder walls.

Prof. Stewart—Referring to the expansion line of the indicator card, how then would you account for this line rising above an adiabatic line drawn through the highest point of the card, when allowance is made for heat lost to water jacket, etc.?

Mr. Ruud—I do not claim that it would not be higher. It seems that the combustion is very nearly complete at the moment of the firing if the mixture is right. The rise of the expansion line above the adiabatic may be due to heat received from the cylinder surfaces and also to a more or less diluted mixture.

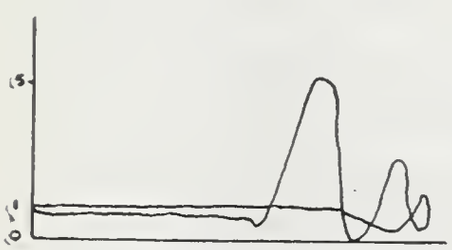
Mr. Neeland—I should like to ask Mr. Ruud if there is any particular amount of compression which would give the best results.

Mr. Ruud—The higher the compression you have within practical limits the better the results.

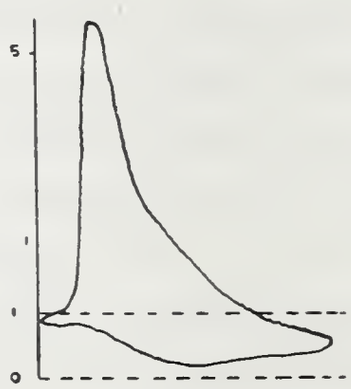
Mr. Bole—Mr. Stillwell was to have been here this evening, and, as his paper bears very closely upon the subject of Mr. Ruud's paper, I would suggest that the two papers be discussed fully in connection with each other at the next meeting. I would advise that the members come fully prepared to discuss these interesting papers.

Daniel Carhart,
Secretary.

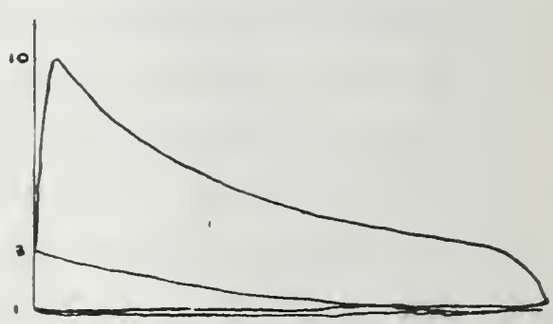
Adjourned.



Lenoir
Fig. 12.



Otto - Langen
Fig. 15.



Otto
Fig. 23.

MINUTES OF THE CHEMICAL SECTION OF THE ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.

The regular monthly meeting of the Chemical Section of the Engineers' Society was held at the Carnegie Library Building, Allegheny, on Friday evening, February 28th, 1896.

The meeting was called to order at 8.10, Mr. J. M. Camp in the chair, thirteen members being present.

The minutes of the last meeting were read by the Secretary and approved.

The advisability of publishing the papers of the Chemical Section separately from those of the other part of the Society was then discussed, and Prof. Phillips offered the suggestion that it would be well to have the paging of all papers published continuous, so that they could be bound together in book form, if necessary.

There being no further business to be transacted, Dr. Karl F. Stahl read his paper upon Hydrofluoric Acid.

HYDROFLUORIC ACID.

BY KARL F. STAHL.

Hydrofluoric acid is, as far as I know, always made by decomposing ground fluorspar with sulphuric acid in cast-iron vessels and absorbing the resulting fumes of hydrofluoric acid in leaden vessels of varying construction, containing more or less water, according to the strength desired.

The commercial acid, containing 40 to 52 per cent HF, is stored and shipped in lead vessels, small quantities in gutta percha bottles. Weaker acid of about 35 per cent. and less can be stored for a limited time in wood and is sometimes shipped in barrels, usually oil barrels. The so-called "chemically pure" acid is packed, in this country, in ceresine bottles, which answer very well, but they must be kept away from the Bunsen burner, as

the melting point of the ceresine is low. In Europe the c. p. acid is shipped, either in gutta percha or platinum bottles, but the acid takes up in course of time mineral and organic matter from the gutta percha and ceases to be c. p—platinum bottles are the best, but require a heavy first outlay.

The impurities, which can hardly be avoided in manufacturing commercial hydrofluoric acid, and are therefore always present, are :

1. *Hydrofluosilicic acid.* This is the most important impurity, not because it does any direct harm in the application of the acid, but because the fluorine combined with silica is perfectly useless. The source of hydrofluosilicic acid is free or combined silica in the fluorspar, which is all dissolved and volatilized by the hydrofluoric acid. It seems almost impossible to obtain spar free from silica. American ground fluorspar contains usually about one and one-half per cent., samples of English spar, which I have tested, were even higher in silica about 3 per cent., while 6 samples of German spar contained from 0.1 to 0.7 per cent. silica. In the rapid determination of silica in fluorspar an analytical problem presents itself, which I have not yet solved to my satisfaction. I use the following extremely simple method :

1 gram. of ground fluorspar, in a platinum dish with a small platinum spatula, is dried at about 130°C., weighed exactly, moistened with hydroflouric acid, stirred with spatula, evaporated to dryness on the water bath, this is repeated, then dried again at 130°C. and weighed. The difference I assume to be silica, which is only correct when free silica is present, but the spar may contain silicates, for instance, clay, in that case a fluoride of alumina would be formed, part of the weight of the silica would be replaced by the weight of the fluorine retained and the silica be found too low. If carbonates are present the error would not be great, for instance

$$CaCO_3\ (100)\ \text{would give}\ CaF_2\ (78),$$

and the silica be found too high. The presence of carbonates

is, however, easily detected and the carbonates can be removed with acetic acid. Galena is often present in small quantities and gives the spar a grayish or bluish color, in that case

$$PbS\ (239) \text{ would give } PbF_2\ (245),$$

an error that would not be perceptible. After all you see that this simple method, to which any careful boy can be drilled in a short time, is likely to give quite acurate results.

The great damage done by silica in the spar is plainly shown by the following equation:

$$\begin{array}{lcccccc} (1) & SiO_2 + 3CaF_2 + 3H_2SO_4 = & SiF_4(HF)_2 & + & 3CaSO_4 & + & 2H_6O, \\ & 60 \quad\quad 234 \quad\quad 294 & 144 & & 408 & & 36 \end{array}$$

You see for every part of silica about 4 parts of fluorspar and 5 parts of sulphuric acid are wasted, or expressing it in money value, for every per cent. of silica at least ten per cent. (4 per cent. for spar and about 7 per cent. for sulphuric acid) should be deducted from the value of the spar.

2. *Sulphuric acid*, which is distilled over in small quantities out of the decomposing vessel, does no harm in the application of the hydrofluoric acid for etching glass or pickling iron. But in analyzing the acid it must be determined, otherwise it would be figured as hydrofluoric acid.

On evaporation and calcining commercial acid should leave but a trace of non-volatile matter.

About five years ago, having made some hydrofluoric acid in an experimental apparatus, I was confronted with the inability to tell what I had made. That is, I could, like any other brother chemist, determine by an elaborate analysis the composition of my product, but I could not find a method, which would have enabled me to do it in a reasonably short time. The old standby of every chemist, Fresenius, is almost silent on the subject. He only gives the following directions for testing acid for analytical purposes: "Hydrofluoric acid should completely evaporate if heated in a platinum dish on a water bath. Neutralized with potash or ammonia it should not give a precipitate."

The first of these reactions would show the presence of any foreign substance that is likely to be present, except muriatic and silicic acid, while the second reaction would show the presence of the latter acid.

Dr. C. Krauch in his valuable book: "Die Prüfung der chemischen Reagentien," gives (2d edition, page 20) directions for a complete quantitative analysis of commercial hydrofluoric acid, which covers the subject well. But this book was not published, or at least not in my possession, at the time I made the experiments, and the method, which I shall describe takes only about one-fourth the time and is even more accurate.

The method for determining quickly the percentage of a liquid by its specific gravity is of little value for two reasons; first, because the methods for determining the sp. gr. of other liquids can only be used with modifications for hydrofluoric acid, as they involve the use of a glass instrument of some kind A glass hydrometer can only be used a few times until the acid has ruined it, picnometers are out of question. Even the temperature of hydrofluoric acid cannot be determined directly with a thermometer; as soon as a glass thermometer is placed into the acid the mercury begins to rise from the heat evolved by the action of the acid on the glass.

I was fortunate enough to find, among the relics of our firm, an old platinum hydrometer, which had been bought years ago with a still and was graduated for strong sulphuric acid. This instrument I opened at the upper end, took part of the ballast out; the graduation I could not change, but by comparison with other hydrometers in sulphuric acid I constructed a table, which gives me for every degree on the platinum stem the corresponding specific gravity. A hydrometer made from pure silver would probably last for a long time. I have seen one made out of German silver, plated with silver, but the hydrofluoric acid got through the plating and ate numerous pinholes into the instrument.

The impurities mentioned above, i. e., hydrofluosilicic acid and sulphuric acid, influence the sp. gr. of the hydrofluoric acid to a very marked degree, so much that the determination of the sp. gr. of an acid of an unknown origin is of little value, but for controlling the process in the works, where the character of the raw materials and the degree of purity of the produced hydrofluoric acid is known, it is of value, provided the conclusions drawn from it are from time to time verified by an analysis. It will not do to depend too much on the sp. gr.

Without taking up your time with a description of the experiments which led finally to the method I now use, I will give you the latter in detail.

The samples are brought to the laboratory in lead cylinders of convenient size, with a handle. These are placed in water of 15° C. After remaining there for at least five minutes, the sp. gr. is taken. Then with the aid of a small platinum tube, serving as a pipette, and chips of filtering paper, to remove a small excess, three portions are weighed out :

1, 2.000 gr. in a very small platinum crucible, holding about 5 cc.

2, 2.000 gr. in a large platinum crucible, holding about 40 cc.

3, 4.000 gr. in a small platinum dish

A. *Total Acidity.* Place the small platinum crucible, covered with its lid, in a large platinum dish, holding about 100 cc.; then run, according to the expected percentage, 25 or 50 cc. normal caustic solution (40 gr. NaOH per liter) from a pipette into the dish, upset the covert crucible and mix the acid and alkali with a platinum stirrer, add two drops of a solution of phenolphtalein (1 gr. in 100 cc. alcohol) and then add more of the normal soda solution from a burette till the colorless liquid assumes the characteristic bright red, which an alkali imparts to phenolphtalein. Place over a Bunsen and heat to about 50° C.; the red color will disappear again ; finally add normal solution from the burette slowly till the red color

remains, even if heated again, which indicates that all free sulphuric acid, hydrofluoric acid and hydrofluosilicic acid has been neutralized. The number of cc. used we call "a."

If litmus is used in place of phenolphtalein, the soda solution has to be added till the color is perfectly blue, but the end of the reaction is indistinct, while with phenolphtalein as indicator it is very sharp.

B. *Hydrofluosilicic Acid.* To the acid in the large platinum crucible (2 gr.) add 5 cc. water (measured approximately), then slowly about 2 gr. (see note 1 below) carbonate of potash, either in small pieces or in concentrated solution; add about 15 cc. of 50 per cent. alcohol and then as many cc. 95 per cent. alcohol as you used water, which will bring the whole to a volume of about 25 cc., containing about 50 per cent. alcohol (see note 2 below); let it stand for at least one hour. Filter (see note 3 below) and wash the gelatinous precipitate, consisting of silicofluoride of potassium, with 50 per cent. alcohol till blue litmus paper ceases to be turned red by the filtrate. Throw the filter with the precipitate into a platinum dish, add about 25 cc. water and warm to about 50° C.; titrate slowly with normal caustic soda solution and phenolphtalein, as described in the determination of total acidity. The number of cc. used we call "b."

Note 1.—The amount of carbonate of potash is calculated to neutralize the acids only partly. To avoid an excess it is advisable to test the liquid with litmus paper, which should show a strong acid reaction. But there should be at least enough potash to form $SiF_4(KF)_2$ with the $SiF_4(HF)_2$. In analyzing acid of entirely unknown composition I take for every cc. normal soda solution used for the determination of total acidity 0.05 gr. carbonate of potash.

Potassium chloride might be used in place of the carbonate, but in that case free hydrochloric acid is formed, in which the silicofluoride of potassium is somewhat soluble.

Note 2.—If the liquid contains more than 50 per cent. alcohol, fluoride of potassium is precipitated; if much less alcohol, silicofluoride of potassium may remain in solution.

Note 3.—I use a platinum funnel, because glass funnels are acted on, but that does not influence the accuracy of the method.

C. *Sulphuric Acid.* Place the platinum dish containing 4 gr. of the acid to be tested on a water-bath under a hood with a good draft and evaporate till acid fumes have completely ceased to be given off. Titrate the remaining syrupy liquid, which contains the free sulphuric acid, cold with normal soda solution, using either litmus or phenolphtalein as indicator. The number of cc. used we call "c."

The reactions involved are as follows:

(2) $HF + NaOH = NaF + H_2O$
20 40 42 18

(3) $SiF_4(HF)_2 + 6NaOH = 6NaF + SiO_2 + 4H_2O$
144 240 252 60 72

(4) $SiF_4(KF)_2 + 4NaOH = 4NaF + 2KF + SiO_2 + 2H_2O$
220 160 168 116 60 36

(5) $H_2SO_4 + 2NaOH = Na_4SO_4 + 2H_2O$
98 80 142 36

Now, the number of cc. of normal soda solution used in the first titration and called "a" represent the alkali necessary to neutralize the hydrofluoric acid, hydrofluosilicic acid and sulphuric acid, and in order to find the number of cc. used for hydrofluoric acid alone, we have to subtract those used for hydrofluosilicic acid and sulphuric acid, but although we used the same weight (2 gr.) for the determination of the hydrofluosilicic acid, it would not be correct to subtract the number of cc. used, because in the silicofluoride of potassium 2 atoms of fluorine are neutralized, and we only neutralize with normal solution the remaining 4 atoms, which are combined with silicium. It would therefore have required $b + \frac{b}{2}$ cc. to neutralize the free acid.

Having employed 4 gr. of substance for the determination of the sulphuric acid, the number of cc used for that determination have to be divided by 2. The number of cc. used for hydrofluoric acid alone are therefore $=a-(\frac{3}{2}b+\frac{c}{2})$, and as each cc. normal solution indicates 0.020 gr. HF and 2 gr. of substance have been used, the number of cc. found by the above formula express, without further calculation, the percentage of free hydrofluoric acid. Therefore:—

$$a-\frac{3}{2}b+\frac{c}{2}=\text{per cent. free hydrofluoric acid.}$$

After the foregoing explanation the calculation of the percentage of hydrofluosilicic acid is an easy matter. 1 cc. normal NaOH indicates 0.055 SiF_4 $(KF)_2$, which was obtained from 0.036 $SiF_4(HF)_2$, having used 2 gr. of substance, 0.036 has to be divided by 2 and multiplied by 100 to get the percentage, or:

$$b\times 1.8=\text{per cent. hydrofluosilicic acid.}$$

The percentage of free sulphuric acid is obtained by multiplying (c) the number of cc. used with 0.048, dividing with 4 and multiplying with 100, or:

$$c\times 1.2=\text{per cent. free sulphuric acid.}$$

Other free acids, muriatic or nitric acid, which would influence the accuracy of the determination, are not likely to occur in commercial hydrofluoric acid and their presence can easily be detected by well-known analytical methods.

To give you an idea of the composition of some of the makes of hydrofluoric acid I have appended a few of the analyses made in course of 5 years:

	1	2	3	4
Specific gravity	.....	1.299	1.264	1.253
Hydrofluoric acid	39.6%	42.2%	44.3%	48.1%
Hydrofluosilicic acid	2.7%	14.9%	10.1%	4.7%
Free sulphuric acid	.....	0.8%	0.8%	4.0%

	5	6	7	8	9
Specific gravity	1.244	1.264	1.282	1.247	1.234
Hydrofluoric acid	48.6%	51.1%	54.2%	48.6%	33.5%
Hydrofluosilicic acid	5.0%	6.8%	8.1%	6.3%	10.6%
Free sulphuric acid.	1.9%	1.4%	1.2%	0.8%	1.6%

1. Oct., '91. Baker & Adamson, c. p. acid in ceresine bottle, 0.005% non-volatile residue.

2. Oct., '91. Manufactured by J. C. Wiarda. Sample received.

3. Nov., '91. Manufactured by J. C. Wiarda. Sample taken from package of 100 lbs.

4. Jan., '92. Manufactured by James Irwin & Co. Sample of lot of 3500 lbs.

5. Mar., '92. Manufactured by James Irwin & Co. Sample of lot of 3400 lbs.

6. Jan., '94. Manufactured by Bender & Aldred. Sample taken from package of 100 lbs.

7. Jan., '95. Manufactured by James Irwin & Co Sample from tank holding 3000 lbs.

8. Oct., '95. Manufactured by James Irwin & Co. Sample from tank holding 3200 lbs. 0.015% non-volatile residue.

9. Jan., '96. So called "pickling acid." Sample received from a foundry.

By comparing analyses Nos. 2 and 7, it can be seen what influence hydrofluosilicic has in raising the sp. gr., although No. 2 has a higher sp. gr. than No. 7, it contains 12 per cent. less hydrofluosilicic acid. Nos. 3 and 6 have the same sp. gr., but No. 6 contains 6.8 per cent. more hydrofluoric acid and 3.3 per cent. less hydrofluosilicic acid. The influence of sulphuric acid on the sp. gr. can be seen by comparing Nos. 4 and 5.

A great difficulty in the manufacture of hydrofluoric acid is the very disagreeable and dangerous nature of the gaseous and liquid acid. The effects of the fumes on the respiratory organs are more injurious than those of other acids. Still more marked are the effects of the liquid acid on the skin. One drop of acid, although it does not make itself felt for a few hours, will, even on the horny skin of a workman's hand, cause a painful inflammation in one-half a day. Against the fumes the workmen protect themselves by respirators, or by the simpler way, which they usually prefer, of tying a hand-

kerchief over nose and mouth and by greasing the unprotected parts of the face with lanoline. The latter is as effective as vaseline and easier to wash off. Against liquid acid rubber gloves afford protection. If liquid acid comes in contact with the skin it should be washed off at once with water and aqua amonia or or an other alkali, which will prevent any injury.

In conclusion I want to say a few words about the different applications of commercial hydrofluoric acid.

The oldest, and up to the present time, the most extensive application, is for etching glass. For this purpose it can be applied in three different ways, either in the gaseous form by suspending the article to be etched ever a mixture of fluorspar and sulphuric acid. This is the oldest way of etching and I believe most burettes, graduated cylinders, e. c. for laboratory use are still marked this way. If applied in gaseous form, the acid leaves the surface opaque, while the liquid acid leaves the surface smooth and transparent. For the production of an opaque surface with liquid acid many empirical formulas are published, and every glass factory, or rather every etching boss, has his own secret formula, but they all aim to produce a mixture of hydrofluoric acid with a fluoride of ammonium, or potassium, or sodium, with which a number of other substances, such as sulphuric, muriatic, or acetic acids, or sulphate of ammonium, or potassium, etc., are mixed, but it seems quite unnecessary. Hydrofluoric acid, prepared for etching opaque, goes under the trade name of "white acid." Lead glass is very rapidly and uniformly etched and acid of 45 to 48 per cent. is usually employed, while lime glass requires stronger acid and more time. Lately acid as strong as 52 per cent HF is employed. "White acid" is much more convenient for application than gaseous acid and acts very rapidly. For instance, can a lead glass chimney be rendered opaque by simply dipping it into the acid for one minute? Lime glass, even with acid specially prepared for it, requires about two minutes' immersion. It is important that the temperature of the acid and the glass should be about 15° C. Parts of

the glass, which are to remain unetched, must be protected; for this purpose a number of substances are in use. Asphaltum varnish is usually employed when the design is printed on paper and then transferred to the glass; for the so-called needle work a mixture of Bergundy pitch and beeswax is used.

A more recent application of hydrofluoric acid is for cleaning castings from sand. These have so far been cleaned either by mechanical means or with sulphuric acid, but the first is expensive, and both ways, in many cases, not satisfactory. The sulphuric acid loosens the sand by dissolving the iron to which it is attached, while hydrofluoric acid dissolves the sand itself, and therefore acts more promptly, and does not cause any loss of iron. It also dissolves the magnetic oxide formed on the surface of the iron very readily, much more so than sulphuric acid. This latter point is important for castings, which have to be worked afterwards with edged tools, the magnetic oxide being very hard. For cleaning castings the acid is diluted to about 1 or 2 per cent. HF: the pickling can therefore be carried on in wooden vessels.

Some of the firms who use hydrofluoric acid for cleaning iron have kindly sent me reports on it. The most interesting parts of these reports I will mention here, with their permission:

Mr. S. H. Stupakoff, superintendent Union Switch and Signal Co., writes:

"We use the acid in the proportion of two and one-half quarts to one-half barrel of water, containing about 25 gals." (Equal to 1 lb. 48 per cent. hydrofluoric acid in 35 lbs. of water; the liquid would therefore contain 1.4 per cent. HF.) "The bath is filled to the top with castings, and they are left in it for about half an hour. We can renew our charge by adding each time one quart of acid."

"We find that the hydrofluoric acid is vastly superior to sulphuric acid, as the latter will not pickle satisfactorily in less than one day, and besides this we use about double the

quantity of sulphuric acid compared with hydrofluoric acid to pickle the same amount of castings." (As the quantities given by Mr. Stupakoff are by volume, this would be equal to 1 lb. of 93 per cent. sulphuric acid in 11 lbs. of water; the liquid would therefore contain 8.5 per cent H_2SO_4, or six times as much as the hydrofluoric acid bath.)

"With the sulphuric acid we experienced a great deal of trouble by obtaining a white sediment on the castings, which was very difficult to remove, even when washed in hot water. This white coating would frequently work through the paint, with which the castings were subsequently covered.

"We had no occasion to try this acid for cleaning any other material but cast iron, with the exception of one instance, when we tried to remove heavy coatings of rust from a lot of mixed material consisting of cast and wrought iron. The hydrofluoric acid did this to perfection and left a perfectly bright surface.

"I can say, in conclusion, that I am perfectly satisfied that the use of hydrofluoric acid for the cleaning of new castings and corroded iron is certainly a success, and I will always prefer it to the old method of pickling in sulphuric acid."

From the engineer of another firm I received the following report:

"The best solution is 1 to 30." (This is by volume, and the bath would contain, as he used 48 per cent. hydrofluoric acid, about 2 per cent. HF.) "As we make no small castings of gray iron, I have only used the acid on malleable castings, with the result that small castings are cleaned excellently in two hours. I have also cleaned castings in a mixture of 1 acid to 50 water" (the bath would contain about 1 per cent. HF.) "by leaving them in over night, but we prefer to clean with the stronger acid. The pickling vat is usually filled up with castings three times before it requires more acid."

"It takes sulphuric acid twice as long with the same proportion" (that is, 1 : 30, which would give a solution of about

5.6 per cent. H_2SO_4), "and then does not eat into the corners as well as hydrofluoric acid; also wastes more iron and does not leave it bright."

For iron, which is to be enameled, the cleaning with hydrofluoric is also advantageous, because it leaves a purer metallic surface than can be obtained with other acids.

I am informed that a large firm in this city is at present making arrangements with a view of throwing out their whole mechanical cleaning plant, in which they have been cleaning 60 tons a day.

Hydrofluoric acid, or its salts, is also used in distilleries to insure a more complete fermentation. Not being familiar with this application, I will quote a few sentences from an article by Dr. Leo Backeland which appeared in 1892 in the Journal of the American Chemcial Society:

"In Europe nearly all important distilleries have adopted the process, and their reports have been very favorable. In general an increase from 8 to 10 per cent. in the yield on alcohol has been obtained, and a more steady and more complete fermentation has been noticed. The production of lactic and butiric acids have been reduced to a minimum. The quality of alcohol has also improved. The use of fluorides does not interfere in the least with the use of slops for feeding cattle. Very small quantities of hydrofluoric acid are used, about 6 grams fluoride of ammonium, or 7 grams 48 per cent. hydrofluoric acid per hectoliter. Twenty grams of 48 per cent. hydrofluoric acid is too much and proved injurious."

The latest application, of which I heard only a few days ago, is for cleaning out oil and gas wells. It seems that the "shooting" of a well sometimes packs the rock so tightly that the hole is dryer after the shooting than before. By pouring about 6 bbls. of hydrofluoric acid (I suppose the acid is used diluted) into the hole, which dissolves the silicates, and afterwards is pumped out again, gas or oil gets an outlet.

During the reading of this paper, Dr. Stahl often inserted

verbal explanations of certain parts, giving illustrations and citing instances by anecdote, which were particularly interesting, and very often the subject of these verbal asides was taken up and discussed by the other members of the Society.

In referring to the severity of the action of hydrofluoric acid upon the skin, Dr. Stahl told some very interesting stories in regard to some of his workmen who had suffered from having the acid brought into contact with the naked skin. Unless such precautions are taken, the action of the fumes on the skin, particularly under the eyes, is extremely severe.

A short and informal discussion upon this subject then followed, in which Mr. Koch, Prof. Phillips, Prof. Aschmann and Mr. Camp took part.

When referring to the etching of glass, Dr. Stahl made some very interesting aside remarks, describing how etching is done in an average glass factory.

When referring to the cleaning or pickling of castings, Dr Stahl illustrated his discourse by some samples of cleaned and uncleaned iron castings which he had brought with him, showing the effectiveness of hydrofluoric acid as a pickling agent. In this connection, Mr. Koch wished to know if hydrofluoric acid could be used to take the bad spots out of chilled rolls, and how much the acid would cost for this purpose; to which questions Dr. Stahl responded that he thought the acid could be so used to advantage. Mr. Lœffler wanted to know if the use of the acid ever made the iron or steel castings rusty, and Dr. Stahl stated that if after applying the acid, the castings were washed in hot water, so as to dry quickly as soon as they come out of water, they would remain bright, but if they were washed in cold water they would rust, just like any piece of bright iron that remains wet for even a short time.

DISCUSSION:

After the reading of the paper a short discussion took place, of which the following is the substance:

THE CHAIRMAN—Why is, for analytical purposes, sulphuric acid always used with hydrofluoric acid?

DR. STAHL—The only reason I can see is to have all the salts as sulphates after the reaction is finished, which is generally the most convenient form.

MR. LOEFFLER—Is the acid used to clean steel castings?

DR. STAHL—It is.

MR. LOEFFLER—In a steel casting with a solid core would it not be a little costly to use hydrofluoric acid?

DR. STAHL—That would depend on the shape of the core, but I think it would be advisable to remove first the biggest parts of it by mechanical means.

PROF. ASCHMANN—In speaking of etching on glass, have you seen the process of the rubber stamp used with the acid?

DR. STAHL—I have made such a fluid by thickening "white acid" with sulphate of barytes. I had some trouble to find a suitable pad, and if the rubber stamp has very small letters it becomes clogged in a short time and will not work satisfactorily.

THE CHAIRMAN—Dr. Stahl has spoken of the impurities of the acid he manufactures; how is it purified for analytical purposes?

DR. STAHL—By distillation in platinum and by using absolutely pure sulphuric acid.

THE CHAIRMAN—Do you use water in your receivers?

DR. STAHL—Yes.

THE CHAIRMAN—Does the gas bubble down into the water?

DR. STAHL—No; we let it come over the top, but I have seen an apparatus on a small scale where it bubbled through the water.

MR. GARRIGUES—How strong can this acid be made?

DR. STAHL—We have made it as high as 58 per cent. HF.

MR. GARRIGUES—I was under the impression that for the etching of glass hydrofluoric acid was being rapidly superseded by the mechanical process of the emery wheel.

Dr. Stahl—That process can be used to advantage for small designs or a few letters, but where the design to be etched is large and elaborate, or the articles of a peculiar shape, the acid process is better. In fact, nearly all etching of globes for lamps and chandeliers, tumblers, etc., is done in this way. It is the most practical process known, the work being cleaner cut than that done by the sand blast, which process is also sometimes used, but with poor results.

Mr. Garrigues—Where do you get the calcium fluoride?

Dr. Stahl—It comes from Illinois; sometimes we import German spar.

Mr. Garrigues—Does it cost much?

Dr. Stahl—The American spar costs, in large quantities, less than one cent per pound.

Dr. Stahl also described the best way in which to build carboys for the shipment of the acid, saying that they were made of sheet lead, but the sides should not overlap the bottom on the inside. Otherwise fluoride of lead is formed in the crevices where the sides and bottom overlap and forces the two sheets of lead apart, causing leaks. He also spoke of the action of the fumes of the acid on corrugated iron of buildings in which the acid is sometimes manufactured, saying that they attack the iron under the paint, causing the paint to drop off in large flakes.

Adjourned.

A. G. McKenna,
Secretary Chemical Section.

Engineers' Society of Western Pennsylvania.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held on Thursday evening, March 19, 1896, at the Carnegie Library Building, Allegheny, Pa. The meeting was called to order at 8 P. M., Mr. W. G. Wilkins in the Chair, and forty-one members and visitors present.

The minutes of the last meeting were read and approved.

The Secretary then read the names of four applicants for membership, which were approved by the Board of Direction, and who will be voted on at the next meeting.

The Society then proceeded to the election of new members, resulting in the election of the following named gentlemen to membership:

G. H. Winslow.....Electrical Engineer
John McGrew.....Civil Engineer
R. A. Rowland.....Manufacturer
P. E. Hunter.....Civil Engineer
H. M. Hooker.....Agent
Ralph Crooker, Jr.....Engineer
C. W. Ehlers.....Civil Engineer
James R. Elliott.....Civil Engineer
E. W. Cunningham.....Civil Engineer
H. W. Bernard.....Chemist

The report of the House Committee was then called for by the Chairman. This call was responded to by Mr. Gustave Kaufman, the Chairman of the Committee, who made a verbal report, which was in substance as follows:

"That the House Committee was hard at work getting estimates on the cost of putting the new quarters for the Society into proper condition for the comfort of all members;

that owing to the size of the house, they feel that it would be advisable to rent the rooms which are not needed by the Society, the rooms on the first floor being desirable as offices, and those on the third floor as sleeping apartments ; that the members of the Society be requested to co-operate with the House Committee in trying to secure suitable tenants for these apartments ; that possession of the premises will be obtained about April 1, at which time the work of repairs will be begun ; and that in about two or three weeks at least the quarters will be ready for occupancy."

Mr. Swensson, Treasurer of the House Fund, stated that up to the present time the subscriptions amounted to about $820, while only about $350 in cash had been received.

The Chairman then called the attention of the Society to the importance of immediately increasing this fund, stating that he hoped each member would contribute his share toward the fitting up of the new quarters of the Society.

Dr. Stahl read the report of the Treasurer of the Banquet Committee, showing that there were about 100 members present at the banquet ; that all expenses connected with it were paid, and a surplus of twenty-four dollars and forty-two cents ($24.42) was in his hands.

On motion the report was received, and the Society voted that the balance in the treasury be appropriated by the House Committee to be used in repairs of the new quarters.

The Chairman then called for a discussion of the papers recently read by Messrs. Stillwell and Ruud, but received no response.

Mr. R. M. Atwater then read his paper upon "The Effect of Coke Oven Construction on Coke."

Mr. Atwater had several drawings and diagrams with him, in relation to the subject of his paper, to which he referred during his reading, and at times made verbal explanations of the different points, demonstrating his explanations by reference to the drawings. He also brought with him several specimens of coke, showing the difference in the quality between that manufactured by the retort oven process and that manufactured by the beehive oven process.

THE EFFECT OF COKE OVEN CONSTRUCTION ON COKE.

By R. M. Atwater.

Mr. President and Gentlemen of the Society of Engineers of Western Pennsylvania:

Prof. J. P. Leslie describes the well-known Pittsburg vein of coal as follows:

> "The Pittsburg region is an outspread of the "Pittsburg coal bed, fifty miles long by fifty miles "wide, within the limits of the State of Pennsyl-"vania. An average of eight feet in thickness for "the whole region looks like a fair one. This gives "eight million tons per square mile, and there are "twenty-five hundred square miles. Allowing fifty "per cent. of the area to be interval, and fifty per "cent. for pillars and bad mining, we may set down "this coal, available for market in the future, at five "billion tons."

On this basis, 2 per cent. of the Pittsburg coal is contained in the Connellsville vein, counting it all as standard, and not over 1 per cent. of the high-grade standard coking coal, yet this 1 per cent. of Pittsburg coal yields 75 per cent. of all the coke made in Pennsylvania, over 8,000,000 tons in 1895.

The object of my paper is to offer methods of coking the Pittsburg coal which will enlarge the boundaries of the standard coking coal to all of the Pittsburg coal fields that bear coal of standard chemical composition. The available coal left in the Connellsville field is estimated to produce about 70,000,000 tons of coke, which, at the 1895 rate, will last ten to twelve years. It is, therefore, only a question of a few years when other coals must be used, especially if the consumption of coke increases as it should increase, and the United States produces coke for the whole western hemisphere. There is, therefore, in the broad view of the question, no controversy between the Connellsville beehive oven and the retort oven. The existing ovens will have completed their useful life before the adjacent

coal is exhausted. So, without sacrifice, they will disappear, and the new construction will take the form of the retort oven. It is this gradual and economical merging of the old method into the new which I desire to present and advocate.

The beehive oven makes no provision for the physical improvement of the coke. It is a broad, shallow basin, in which the coking coal follows out its own natural course. So far as the quality of the coke depends upon the oven, it is as primitive and unimproved a construction as when it was first devised.

Consequently, the beehive oven is a happy-go-lucky oven, and in the lottery of its application the prize fell to the narrow and limited Connellsville valley, or, more strictly, to the middle of this valley, for both the north and south ends are not of equal quality with the so-called "standard coke."

In this fortituous application of the beehive oven, great regions of coal of equal chemical purity with Connellsville have laid dormant, or sold at lower prices, because they did not make hard coke. If this one lacking quality of structural strength can be added to the coke, it will bring areas of coal land ten times as large as the Connellsville field up to the Connellsville grade for coke. This will add 25 per cent. to the value of such fields.

In the beehive oven a shallow basin 12 feet in diameter is filled with coal to the depth of 24 inches. As it gradually fuses into coke, the mass swells to a height of about 30 inches. If, on quenching, it falls back to about the original bulk, it makes a hard coke. If it does not, it makes a soft coke. This is the apparent difference between the Connellsville coke and the other coke from the Pittsburg vein.

Considering this operation in the retort oven, which is a narrow chamber about 18 inches wide and 6 feet high, when the coking coal swells it cannot expand. It is compressed laterally between the narrow oven walls, and vertically by the overlaying weight of over 5 feet of coal. The result is that

the coke which is soft when coked in beehive ovens is hard when coked in retort ovens.

Further, the hydro-carbon gases, escaping through the mass of the coke in the beehive oven, form vertical passages or cells, and make their way in channels like the passages in a corn-stalk, or other endogenous plant. These passages are the cells of the coke structure. As they are parallel to the lines of pressure of the overlaying coal, they have free course, and assume their full size. On the other hand, in the retort oven, the volatile gases pass off first horizontally from the sides of the oven, and uniting in the central part of the mass, pass up to the outlet of the oven through a middle line of cleavage. The whole weight of the overlaying mass of coal presses upon these passages vertically, and so compresses the cells, and adds to the density of the coke. The result is therefore clearly evident that the retort oven adds density and structural strength to the coke. It will, therefore, carry a heavier burden in the furnace, both in actual height of charge, and in the proportion of ore to coke, without giving way.

This improvement in the physical quality of the coke is accompanied by a further improvement in its chemical composition. The three characteristic impurities of coke are sulphur, phosphorus and excess of ash over that required for structural strength. In the beehive oven, not only is all the surplus volatile wasted, but there is a greater or less destruction of the fixed carbon. This varies with good or poor operation of the ovens from 5 per cent. to 40 per cent. This loss is inevitable with an internally fired oven.

On the other hand, in the retort oven, there is an actual gain in the amount of coke produced over the theoretical yield of the coal in the fixed carbon and ash. This gain is caused by breaking up the hydro-carbon gases and the deposit of graphitic carbon on the surface of the coke. This gain amounts to from 5 per cent. to 15 per cent. over the ordinary practice of beehive ovens.

In proportion as the product of coke from the retort oven exceeds the product from the same coal in the beehive oven, the amounts of sulphur, phosphorus and ash in the retort coke will be decreased, since these impurities start from the coal, and remain, to a large extent, in the coke.

We may therefore sum up the effect of the coke oven construction on the resulting coke as follows: The yield of coke will be increased by the greater rapidity of coking, which never exceeds 24 hours, and may often require only 18 hours, and also in coking part of the volatile. Second, the quality of the coke is improved chemically, by reducing the impurities, and physically by increasing the structural strength of the coke.

Considering the Fourth Pool coals as tributary to the Pittsburg and Valley region, the coals of the upper Monongahela and West Virginia as tributary to the blast furnaces in the Ohio Valley; the Western Maryland coals as tributary to the Eastern Pennsylvania and Maryland furnaces; and the Pocahontas coals as tributary to the Virginia and western furnaces—the results are of fundamental importance. The improvement in the quality of the coke produced should raise the value of the coke by at least 25 per cent., and the increase in the product of coke, which may be fairly stated from present common practice as 20 per cent., is equivalent to a profit of 20 per cent. over that obtained by present methods. For every five tons of coke produced by present practice, one additional ton will be produced by means of the retort oven, and this extra ton, requiring no extra mining or manipulation up to the time of shipping, is all profit.

Still, it must not be forgotten that no oven will make good coke out of poor coal. The fountain cannot rise higher than its source. I have no doubt that the retort oven will produce coke better than Connellsville, from coals that are better than Connellsville, if such can be found. The test of 1,500 tons of Semet-Solvay coke from Connellsville coal at the Buffalo furnace demonstrated conclusively that a coke which did not

represent the best practice of the retort oven was equal in the blast furnace, both in calorific power, in burden-bearing, and in the quality and amount of the iron produced, to the best, selected 72-hour coke that the Connellsville region was able to offer. This is the verdict of the able and impartial umpire, Mr. John Fulton, in his report to the Johnson Company, in whose interest he conducted the test. When the retort oven shall have been developed to its full possibilities on Pittsburg coals, as the beehive oven has been, a new standard coke will be the result, and the beehive may not be in it.

COMPARISON OF THERMAL ECONOMY OF RETORT AND BEEHIVE OVENS.

For the purpose of the comparison assume a Connellsville coal having the following analysis:

Volatile matter	31.9%
Fixed Carbon	61.6
Ash	6.5

This coal coked in the retort oven yields 76.6 per cent. of large coke and breeze (dry), and 9250 cu. ft. of gas. The same coal coked in the beehive oven yields, say 65 per cent. of dry coke and breeze and no gas.

The 76.6 per cent. yield of coke from the retort oven contains as follows:

Analysis of Coke.		Lbs. per ton Coal.
Volatile	1.92%	29.41
Fixed Carbon	88.21	1351.38
Ash	9.87	151.21
	100.00	1532.00

It is plain that whatever may be the yield of coke in any oven from a certain coal, the pounds of ash per ton of coal must be the same; therefore, assuming the same volatile in the beehive coke as in the retort coke the 65 per cent. yield from the beehive oven will give a coke of the following composition:

Analysis of Coke.		Lbs. per ton Coal.
Volatile	1.92%	24.96
Fixed Carbon	86.45	1123.83
Ash	11.63	151.21
	100.	1300.

Disregarding the value of the volatile in the coke, the thermal value of the products of the two ovens is as follows:

B. T. U. in gas from one ton coal coked in retort oven	5,117,498
B. T. U. in fixed carbon in retort coke	19,595,010
	24,712,508
B. T. U. in gas burned for heating ovens	2,047,000
	22,665,508
B. T. U. in fixed carbon in coke from 1 ton coal in beehive	16,295,535
Balance in favor of retort oven	6,369,974

The heat units in a ton of coal may be roundly stated as	24,000,000
Of which the fixed carbon contains	17,000,000
And the volatile	7,000,000
The theoretical yield of heat units in the coke from one ton of coal in B. H. coke is	17,000,000
But in B. H. oven practice there is a destruction of fixed carbon of	1,000,000
Leaving the total heat units in the coke obtained from one ton of coal in B. H. oven	16,000,000
On the other hand, in the retort oven, there is a gain of fixed carbon of	1,000,000
Making the total heat units in the coke obtained in the retort oven	18,000,000

Of the heat units in the volatile, which amount to	7,000,000
The process of coking requires about 40 per cent. or	3,000,000
Leaving a gain of heat units from the volatile in retort oven of	4,000,000
Adding to this the gain of heat units in the fixed carbon	2,000,000
Shows a net gain of the retort oven over the bee-hive of	6,000,000
Equivalent to a gain of total heat units in the coal of	25 per cent.
And to a gain of heat units over bee-hive results of	39 per cent.

THE SEMET-SOLVAY RETORT OVEN.

Among the various retort ovens that are offered to American engineers and operators, the classification may be broadly made between the recuperative, horizontal flue ovens and the regenerative ovens with vertical flues.

A metallurgical engineer, considering de novo the operation of coking coal, would certainly not consider the heat of the regenerative furnace as requisite for the low temperature of the coke oven, which rarely exceeds 1500° C. or 2800° F. (as given by John Fulton). The addition of the regenerative furnace was an afterthought to overcome the loss of heat in penetrating the thick flue walls of fire-brick. Its inventor has himself already abandoned it, and now recommends recuperation or continuous regeneration with horizontal flues. Setting aside its expensive initial cost, its liability to serious injury from careless operation, and the expensive repair charges incurred, it is, from a simple engineering standpoint, a needlessly complicated construction. It seeks to accomplish by a high temperature, applied through a very limited area, that which the recuperative furnace accomplishes by a uniform and more moderate temperature through a space ten times as

great The vertical flues of the regenerative construction must do their work in a single ascent and descent through the space of 6 feet, representing the height of the oven, a total of 12 feet working distance. In the recuperative construction, with horizontal flues, the burning gases traverse three horizontal flues along the side of the oven, each 30 feet long, and return under the sole of the oven, making a total of 120 feet through which the heat of distillation is applied to the mass of the coking coal. The initial heat in these horizontal flues is not as intense as in the regenerative vertical flues, but as they do their work through a thin tile of only $2\frac{3}{4}$ inch section, while the vertical flues are $4\frac{1}{2}$ inches thick, it is easy to see that the temperature produced in the interior of the oven is much easier attained by the recuperative construction. The solid masonry construction between and above the Semet-Solvay ovens is itself a recuperator, in addition to the heating of the incoming currents of air adjacent to the chimney flues of the Semet-Solvay oven. Together they form a natural recuperation of equal effectiveness with the checker work of regenerative furnaces.

It is well known that the Siemens Regenerator does not produce a uniform temperature, and that this temperature varies in proportion to the periods of the reversal of the currents. For high temperatures these reversals are frequently made at 15-minute intervals, thus overcoming as far as possible the up-and-down result to the temperature of the working furnace. When these periods are extended, as in the regenerative coke oven practice, to two hours, it is evident that at the times just preceding and just following the reversals, the resulting temperature in the oven must be subject to large variations. On the other hand the heat conducted to the oven through the horizontal flues by the continuous method is uniform for every section of the furnace. Moreover, this uniform temperature is under very complete control, since, by the admission of proper proportions of gas and air to any one of

the three flues, the resulting temperature of each individual flue is under control. Any chemist will understand that the heat of fusion and distillation is most effectually applied at the bottom part of the retort, and this effect is produced, as seen in the temperatures on the diagram, in the flues of the Semet-Solvay oven.

On the other hand, it is equally evident that where burning gases rise through vertical flues, and are then diverted by baffling plates, the temperature is greatest at the baffling point, and it therefore necessarily follows that in the regenerative coke ovens the highest temperature is produced at the top of the flues, the reverse of the proper application of the heat to the purpose required. When through carelessness or willfulness the periods of reversal become extended, as every Siemens furnace man knows from his own experience they occasionally are, the result is a melting of these flues, and enormous injury to the construction. It is such considerations as these that prompted the remark of Mr. Darby, of the Brymbo Steel works, Wales, that if it is possible to avoid the regenerative construction, enormous trouble and expense will be avoided.

Mr. Fulton states as his conclusion about the comparative working of different retort ovens, that the Semet-Solvay oven is 30 per cent. quicker in operation than any of its competitors. As evidence of this, we may point to the 2,000 tons of Connellsville coal for the Buffalo test, coked in 20 hours; to 100 tons of Pocahontas coal coked in 16 to 18 hours; to 100 tons of Fourth Pool coal, in a recent experiment, coked in 20 to 22 hours. From these results we can confidently assert that a Semet-Solvay oven will produce 2,000 tons of coke from Pocahontas coal in one year, or 1,600 tons of Connellsville or Fourth Pool coke. We have yet to hear of any other oven in America or Europe equaling these records by considerably above 30 per cent.

This rapid operation of the Semet-Solvay oven affects both the original and the operating cost. It will require twice

as many ovens making 36 or 48 hour coke as Semet-Solvay ovens making 18 to 24 hour coke. The operating expenses in the Semet-Solvay ovens will also be greatly reduced. These are vital elements in American constructions. The Connellsville coal from the Valley mine sent to Europe in 1893 required 38 hours for coking in the regenerative oven with vertical flues. The coal from the same mine in the Syracuse ovens required only 20 hours.

When the direct object of the retort oven is the production of fuel gas as well as coke, this rapid operation becomes of greatly increased importance. The distillation of the volatile is not equal through even periods of the time of exposure in the oven, but proceeds with great rapidity during the first half of the time, and very slowly toward the close of the coking operation. It is, therefore, possible, by shortening the coking period, to coke two charges in 24 hours, and produce nearly double the amount of gas, and coke, which, for many purposes, will command as high a price as blast furnace coke. In the Semet-Solvay oven, this operation is practicable without any change in construction, but by a simple difference in operation.

In conclusion, we may consider it as fairly demonstrable, that, whether for coke or gas, the Semet-Solvay oven is constructed upon correct principles; that it is, both in construction and operation, more economical than any of its competitors; and that it is available as a working device to the coal miners and blast furnace operators of the Pittsburg field as a profitable investment.

DISCUSSION.

The Chairman: Mr. Atwater, you speak in your paper of a yield of 80 per cent of coke on an average from the retort oven; is that the general average of the retort process, or only from a particular coal?

Mr. Atwater: The average yield of the retort process, Mr. Chairman, depends entirely upon the quality of the coal used.

THE CHAIRMAN: Well, for instance, what is it with Connellsville coal?

MR. ATWATER: With Connellsville coal, it averages from 73 to 76 per cent.; with Pocahontas coal from 83 to 86 per cent., etc., the average being about 80 per cent.

THE CHAIRMAN: What percentage of ash do you get from Connellsville coke made in the by-product oven?

MR. ATWATER: From about 9 to 10 per cent. on Connellsville coal.

A MEMBER: I should like to ask whether the gas obtained can be conveyed any distance easily and fired without previous heating, as in ordinary producer gas, or if it is necessary to put it through regenerators?

MR ATWATER: It is entirely practical to run the gas through re-generators, if desired. It is a very rich gas, however, and it is not necessary to do so. It is similar to natural gas, which you know is not usually put through regenerators. This serious difficulty is then done away with in coke gas.

A MEMBER: Is the yield of ammonia affected by the heat of the oven?

MR. ATWATER: The liberation of the ammonia is not simultaneous with the volatile. The ammonia passes off very slowly at first. You may charge your coal into a hot oven and the ammonia is not affected.

THE CHAIRMAN: Can your ovens be run by cheap, unskilled laborers? It seems to me that your men would have to be skilled workmen.

MR. ATWATER: Oh, no, not at all, Mr. Chairman. We have a force of 20 men at our works, only one of whom is a skilled workman. They like their work. It is necessary to have only one skilled workman in charge of a plant; the others need be only laborers.

MR JOHNSTON: I should like to ask Mr. Atwater in regard to the cost of the retort oven as compared with the beehive oven, and the life of each.

MR. ATWATER: The beehive oven costs about $300.00; the retort oven about $3,000.00. The beehive oven yields from 300 to 500 tons, while the yield of the retort oven as stated in the paper from Connellsville coal is about 1,600 tons, about four times as much. As to the durability, Mr. Wilkins informs me that after the second year, the beehive oven has to be repaired. We have run the retort ovens in Syracuse for three years without repairs. It is simply the inner lining of tiling that wears out in the retort oven, and this can be very easily repaired in a very short time and without stopping the work of the whole plant. In Europe there is a plant which has run for eight years without repairs. I think I may fairly state that the retort oven will run for 10 years without repairs, and then nothing more will be required except the retiling of the flues.

MR. KOCH: What is the analysis of the fuel gas? Is it rich in hydrocarbons?

MR. ATWATER: The analysis of the fuel gas is as follows:

CO_2	C_2H_4	O	CO	H	CH
1.41	36.11		6.49	53.82	2.24

MR. KOCH: I wish to congratulate Mr. Atwater upon the arrangement of his flues for the coking of coal. It is a most excellent one, and in my opinion surpasses anything I have ever seen in that line. I should like to ask if you make any further use of the gas that passes off?

MR. ATWATER: When the gas reaches the chimney flue it is only 1,000° F., because it has been cooled by contact with the cold air flues before reaching that point, and it then passes under the boilers and enters the chimney at 500° F.

MR. KOCH: In reference to the lining of your flues, I have this to say, that our fire brick and tiling here in America are so far superior to anything in Europe, that if they last 10 years there, then they will surely last 20 years here, as I have found that our fire-brick are excellent for lining.

MR. ATWATER: The foreign tile has served us so well that we have felt that we could not experiment with other tile, but what Mr. Koch says only goes to increase the superiority of the retort oven over the beehive oven in America.

THE CHAIRMAN: Is it not, Mr. Koch, merely a question of price as to the quality of the fire-brick in this country?

MR. KOCH: No, I have not always found it so.

A MEMBER: About what is the surplus volatile per ton?

MR. ATWATER: I think it is possible for us to say that there would be about 4,000 cubic feet from a ton of Connellsville coke. It is customary to state that somewhat in this way: that thirteen parts of the volatile are required to do the operation of coking. You will, therefore, see in coal with thirty per cent. volatile, forty per cent is required, and on this basis if there is 9,000 cubic feet in a ton of Connellsville coal, there should be about 5,000 cubic feet surplus, but I state it as 4,000 cubic feet simply because I wish to be on the safe side. The whole question depends entirely upon the volatile.

A MEMBER: I should like to know, Mr. Atwater, if a ton of your coke will melt the same quantity of iron in the same time that the other coke will?

Before replying to that question, Mr. Atwater referred the member to a passage in Fulton, Work on Coke, page 340. He then said: A ton of retort coke is equal to a ton of beehive coke, but a ton of coal turned into retort coke will produce more than a ton of coal in the beehive process.

MR. MCGARY: How does the cost per ton of coke compare in the two processes, I mean, of course, when the coke is all ready for shipment?

MR. ATWATER again referred the member to Fulton, who states that the saving will be about nineteen cents per ton. He then said: I am of the opinion, personally, however, that it is nearly double that. I think I can safely say that there is one dollar economy per ton of coke in the retort oven in Pittsburg when the saving in freight is included.

MR. SWENSSON. How is the coke removed from the retort? Is it not a troublesome and expensive process?

MR. ATWATER: I think that if you were familiar with the beehive oven you would much prefer the retort oven as to the matter of removing the coke. It is very easily done by ramming and in a very short time. It can be done in five minutes and is not expensive.

MR. MCGARY: In relation to the cost, you give the relative prices as $300 for the beehive oven, and $3,000 for the retort oven; is that the price of the oven alone, or does it include the cost of by-products, etc.?

MR. ATWATER: The prices given are for the whole plant. The plant will stand you at $3,000 per oven.

MR. KOCH: How bad a coal can you use in your ovens? A friend of mine has been using coal that is absolutely useless for anything at all, and can make good coke out of it.

MR. ATWATER: I may say that the retort coke oven was invented in order to coke coals that were considered of little value. Its prime object was not to get by-products. Its object was to make coke out of coals that could not be coked in any other process. We are making over 80 per cent. of coke in our ovens out of Blossburg coal that could not be coked profitably in the beehive oven.

MR. PURVES: Do you expose the coke to the air when cooling, or do you cover it with ashes as is sometimes done?

MR. ATWATER: The coke is generally discharged on a platform in the open air when cooling.

MR. FLANAGAN: Can you give a description of the operation of the oven as to the charging and the ramming off?

In reply to the question, Mr. Atwater referred the members to the drawings which he had with him, and some of which he distributed among the members. He also gave a brief outline of the process by referring to the drawings, which are published in the Semet-Solvay Co's. descriptive circular.

THE CHAIRMAN: Do you charge the oven with "run-of-mine" coal, or do you crush it?

MR. ATWATER: We prefer slack. It works best.

Adjourned.

DANIEL CARHART,
Secretary.

MEETING OF THE CHEMICAL SECTION.

The regular monthly meeting of the Chemical Section of the Engineers' Society of Western Pennsylvania was held in the Carnegie Library Building, Allegheny, Pa., on Friday evening, March 20th, 1896. The meeting was called to order at 8.35, nine members and one visitor being present, Mr. J. M. Camp in the Chair.

The minutes of the last regular meeting were read and approved.

The Chairman on behalf of Prof. Phillips, Chairman of the Committee on Methods, who was unable to be present, made the following report:

"That several more papers are now ready for the printer, and that other papers have been received; and that members of the Society knowing any new chemists hereabouts who would contribute papers, be requested to send their names and addresses to the Secretary, in order that they may be communicated with upon the subject."

On motion of Mr. Wilkins it was decided that each non-member contributing papers be allowed ten copies of his paper, together with a copy of each paper included within the same series as his own.

Mr. Wilkins then reported on behalf of the Committee on Chemical Literature:

REPORT OF COMMITTEE ON LITERATURE, JOURNAL AMERICAN CHEMICAL SOCIETY, MARCH, 1896.

"Third Annual Report of Committee on Atomic Weights," by F. W. Clarke. (74 elements reported on).

"Method for Determination of Carbon in Steel," by Andrew A. Blair.

"Remarks on the Volumetric Determination of Manganese," by George C. Stone.

"History of Electric Heating Applied to Metallurgy," (a review by Frederick P. Dewey), *American Chemical Journal*, March, 1896.

"Determination of Sulphur in Illuminating Gas and Coal," Chas. F. Mabery.

"Standardization of Potassium Permanganate and Sulphuric Acid," H. N. Morse and A. D. Chambers.

Mr. Charles Keller then read his paper on "The Manufacture of Glue."

THE MANUFACTURE OF GLUE.

A glue factory is a very interesting place and furnishes food for constant thought and observation, although in these progressive days its methods are pretty well reduced to a science, despite the fact that in the minds of a majority of people a "glue factory" is a place where old horses are sent, and synonymous with all that is disagreeable.

Glue is made from the various animal offal from tanneries, packing houses, etc. This offal or by-product is called Glue Stock, and comprises many different kinds. From tanneries the stock is principally what is called fleshings, which is the part scraped or shaved off the flesh surface of the hide in reducing it to an even thickness; from this source also come the hide-pieces or trimmings from the rough edges and corners of the hides. From packing houses the glue stock is principally bones, such as the plates, head, feet and shanks, but large quantities of sinews come from this source also. By sinews is meant the chords from the knee down to the foot. The horns also are usually left on the head, and go with it to the glue factory, where they are chopped off, thrown into boiling water to loosen the pith, and are then sorted and dried, to be sold for making combs, etc. The slugs make a very fine glue stock. The hoofs also go with the feet, and are loosened by hot water, afterwards being steamed under pressure and then dried and ground into hoof-meal, which runs high in nitrogen and is used

in mixed fertilizers. The hides from the packing houses go to hide trimmers, who trim off the heads, (called pates) shanks and tails. The latter are called switches, and are used in making curled hair; the two former go to the glue factory. After the curled hair maker has cut the hair off the switches, he sends the remainder to the glue factory as tails. A great deal of glue stock is also imported from South America, in the shape of dried hide cuttings, fleshings, etc. Glove factories furnish large quantities also, as do whip makers, saddle-tree factories and all kinds of manufacturers who use raw hide; consequently there is the glue stock from all kinds of animals, and it is classified as cattle, calf, sheep, goat, coney horse, hog, etc. The value of the different kinds varies with their source; cattle and calf are esteemed the most, the rest ranking about alike.

The substance in animal matter from which glue is obtained is practically the same, at least has the same chemical composition

$$C_{41}\ H_{67}\ N_{13}\ O_{16}.,$$

but occurs in different degrees of density in different kinds of stock, and the glue therefore differs in physical properties according as it is made from the hide of an old bull or a young calf, though having the same chemical characteristics whether made from old or young cattle, or from hide or bone. In hide, sinews, etc., the connective tissue yields the glue, the epidermis being insoluble, like horn and hair. In bones it is the tissue called osseine, I think, corresponding to connective tissue. Both these bodies form insoluble compounds with tannin. For this reason leather scraps are of no use to the glue boiler. It would be an endless subject almost to consider the treatment of all the various kinds of glue stock, but as one kind will give a general idea of all, I will try to describe that given hide pieces, pates, etc. These come, we will say, wet salted from the hide trimmer. They are first cut up into small pieces by means of a rag cutter such as used at paper mills for cutting up old ship cables, etc., and are, and have to be very strong and compact.

After the cutting the stock is washed in a cone roller mill until free from salt, blood and dirt. The blood is much more easily removed by allowing the stock to stand over night in water, but large quantities of water are required in the washing, and in passing I would note that pure, clear water is an essential to good glue making. After washing the stock is put in lime vats. These are built about 6 ft. by 6 ft. by 6 ft., sunk level with the surface of the ground and sewered. About 2 to 3 bushels of fresh burnt lime are slaked in a vat, then about $2\frac{1}{2}$ ft. water added, and the mixture well worked with a plunger. When cold the stock is shoveled in, care being taken to thoroughly incorporate the milk of lime with it, and when the vat is full it is covered with several shovelsful of air-slaked lime, and left to itself for 3 to 4 weeks. The lime dissolves the sheath or skin of the bundles of connective tissue, which then absorb water, and the stock becomes very much swollen. When in the experience of the operator the process is finished, the stock is thrown out of the vat and thoroughly washed, free from lime, the final small residue of lime being neutralized by H_2SO_4. This is somewhat difficult to do exactly, as the outside of the stock may show an acid reaction while the inside may be strongly alkaline. The best way to accomplish the desired result is to use an excess of acid in the mill, let soak over night, and then wash out the excess. After washing (which, with the liming is the most important part of glue making, no amount of skill making it possible to turn out good glue from an improperly prepared stock) the stock is put into the boiling tanks, about 6 ft. diameter by 6 ft. deep, having perforated false bottoms 6 or 8 in. above the true bottom, and an open steam pipe between the two. Here it is allowed to drain over night. In the morning steam is turned on very gradually, and soon a liquid appears gradually rising as the stock melts down into soup. As soon as this is found by the feel and appearance to be strong enough, it is drawn off into the settling boxes, large square or oblong wooden tanks with tight steam coils, where it is

kept for several hours to separate grease and other impurities.

In the meantime, some water is run into the boiling tank, and the residue from the first boiling is boiled up again, till thick and strong enough, when it is also run off, and the process repeated until all the glue is dissolved. Three boilings generally accomplish this, though in some factories where evaporators are used to concentrate the glue soup, 10 or 12 boilings are made, each one very short, in order to get the glue away with the least possible exposure to heat. The first boiling is always the best in quality, the glue deteriorating in proportion to the number of boilings. When the grease, etc., has been removed, the soup is run into iron coolers 6 in. by 10 in. and 3 ft. to 6 ft. long, and left over night. If the process has been successful, in the morning the contents of the coolers will be found to have set into a stiff jelly, which is then cut into sheets, by piano-wire stretched in frames, as far apart as the sheets are to be thick. The sheets are then put by hand upon galvanized iron nets 3 ft. by 6 ft., or any other convenient size. These nets are stretched on frames of wood, and have blocks or pins 2 in. or 3 in. long at each corner. As filled they are piled one upon another on trucks, and run into the drying alleys which are built as wide as the frames are long, and as long as the capacity of the works may require. At one end of the drying alley is a fan or blower, which forces a strong blast of air through the glue. Arrangements are made to heat this air. When the glue is first run into the alley, no heat is used, but after a skin has commenced to form the heat is increased. Care must be taken to not use too much, or the glue will melt and run through the nets. Glue, when put into the alley, may contain anywhere from 60 to 95 per cent. of water. When dry, which requires from 12 to 36 hours, according to the thickness of the cut, it will still retain 12 to 14 per cent. This is only apparent by heating it to 100°, but the glue will absorb moisture if in a damp place. After the drying, it is stripped from the nets and either broken or

packed in sheet form. Usually it is broken, and is often ground to powder, being much more easily dissolved in that shape. When packed in sheet form it is generally cut very thick, so that, when dry, it is from an eighth to three-sixteenths of an inch thick.

After the glue is finished, the testing remains to be done in order to grade it. The grades are arbitrary standards which take into account the appearance, taste, smell, jelly strength and water absorbing properties. Cooper's glues are generally used, as far as my experience goes, as the standards by which other makers grade their product. Fifteen or twenty glues are tested at one time. First, the samples are powdered, and a certain fixed weight of each taken and placed in a beaker. Then a fixed proportion of cold water is added, the proportion of glue to water being about 1 to 4, and sufficient is used to make a volume of 150 cc., the same proportion and amounts being always used. The samples, with water added, are placed in an ice box over night. They will then be found to have absorbed more or less water, according to the quality. To determine this amount the water is drained off and the glue weighed, giving per cent. of water absorbed, which is higher as the glue is better. The glue is then put back into the same vessel with the water which was drained from it, and placed in a water-bath of about 80°. When all the samples are melted, each one is tested for reaction with test paper. They are then run through the running test, which is to place the melted sample in a tube of about $1\frac{1}{4}$ in. diameter and 12 in. to 14 in. long, tapered off at one end to an orifice of 1-16 in. or thereabout, and note the number of seconds required for its passage. This gives a relative comparison of the viscosity of the solutions, the longer time required indicating the better glue, and must, of course, always be done at the same temperature. After this the samples are stirred violently with a glass rod, and the depth of foam on each, if any, is noted. This gives an idea as to whether the sample, if used on a brush machine,

would foam out. (Note—What causes glue to foam?) Then the samples are all set away in the ice-box over night again. Next day they are tried for strength of jelly, by observing the weight which is required to force a disk of $\frac{3}{4}$ in. diameter through the surface. This is done by means of an apparatus consisting of a vertical rod running in guides, and having a funnel on top, and a disk soldered to the lower end at right angles to its axis. The beaker containing the jelly is set under the apparatus so that the disk rests on the center of its surface, and shot is poured into the funnel until the surface of the jelly breaks. This weight is more as the glue is better.

When the glue is to be used for making matches, lithograph paper and some other uses, it must also be tested for grease, which is done by making a tolerably thick solution of the sample in hot water, adding some pronounced color ground in distemper, and brushing with a clean brush some of it on a piece of white, unsized paper. No spots or streaks must show in order to pass this test. An ether extraction would be of no use for this test, as very few glues have enough grease in them to show with ether. All these tests except the last named are only comparative, but they are very good guides in selecting glue for certain purposes and in furnishing a uniform quality to consumers. Sometimes though, two glues may be identical in appearance and all the tests, but when put to use one will work and the other not. That is one of the things the reason of which a great many glue makers would like to know, no satisfactory explanation being known. A great many causes make differences in the quality of glues made from day to day from the same stock, such as length of time boiled, excess of lime or acid, length of time allowed to stand before running into coolers, etc. The only way to obtain uniformity in actual quality as well as in appearance is to have absolute uniformity in all the various steps of the manufacture.

The foregoing is an outline of the subject under consideration, and is the same in its general details for all kinds of

stock. Bones are boiled either with or without crushing, with open or closed tanks. Where the manufacture of bone meal is an object, the boiling is done in open tanks often, and is done more especially to get the grease out of the material, the glue soup being saved and worked up as a by-product of low quality. Where glue is the object, the bones are crushed and leached out with acid, a very superior artic'e of glue being obtained, and phosphate of lime made as a by-product. Large quantities of glue are also made from fish bones and scrap along the coast of Massachusetts and Vermont. The liquid glues on the market are mostly made from this material, and are as a rule very tenacious. Gelatine, which is only glue made with great care as to cleanliness, is made from calf stock and bones chiefly. Its cost is very little more in the making than glue, and I have seen plenty of glue made that for all practical purposes is as good as gelatine.

The residue which is left in the tanks after the glue has all been extracted, consists of the insoluble portions of the hide, such as hair epidermis, etc. It is pressed to extract the grease as much as possible, hydraulic or screw presses being used, and is afterwards treated with superheated steam or sulphuric acid to reduce it to a condition such that it can be pulverized and used for fertilizer, its nitrogen making it valuable for this purpose. Ammonia is sometimes made from it also, by the dry distillation process, and very often it is used for fire under the boilers. Where coal is worth $2.50 per ton, it is worth about $1.50 per ton for this purpose.

I need not detail the numerous purposes for which glue is used, only to mention the most important, such as in furniture factories, paper mills, matches, carpet works, straw hats, printers' rollers, etc. Another industry which uses large quantities, is a ready-mixed (all but water) wall plaster. Stucco work, picture frame mouldings, etc., use a great deal, not to say anything about a great many articles of food and confectionery.

DISCUSSION.

MR. KELLER: Can you tell me what makes the glue foam? I have never been able to account for this myself, and should like to have your opinion upon it.

MR. MENOUGH: Can you find nothing that will remedy it when it does foam?

MR. KELLER: No. You might remedy it for the time-being by using either oil or ether, but not permanently.

THE CHAIRMAN: What is the food value of gelatine?

MR. KELLER: Its food value is practically nothing. If fed upon nothing but gelatine, one would starve to death in a very short time.

THE CHAIRMAN: Then why do they give it to sick people and invalids?

MR. KELLER: Oh, it simply serves as an appetizer, or as a conveyor of something else, such as wine, etc.

MR UNGER: In the manufacture of gelatine, do they in any way bleach it?

MR. KELLER: No, they do not. They simply preserve absolute cleanliness in its manufacture. This is absolutely necessary, and if it is prepared properly, it will not have any odor. Glue decomposes very readily, and especially in the spring of the year, and this decomposition causes most of the odor. In order to overcome this, most glue-makers use an antiseptic, such as sulphate of zinc, hydro-naphthol, corrosive sublimate, or chloride of zinc.

MR. GARRIGUES: In describing the process of manufacture, you mentioned the solution of the connective tissue and the substance surrounding the bone, and later of the solution of the substance in water; what effect have the different natural waters on this?

MR. KELLER: They have practically no effect at all.

THE CHAIRMAN: In making gelatine, do you not have to clarify it?

Mr. Keller: Gelatine must always be clarified. This is commonly done with blood.

Mr. Unger: When skimming off the grease from the glue soup, do you allow it to get cold?

Mr. Keller: It is skimmed off while hot and done repeatedly until it is all off.

Mr. Garrigues: By an experiment I once made I discovered that the difference between horn and hoofs and gelatine and osseine, of which you speak, is that the horns and hoofs contain sulphur in a more or less degree. Is that not so?

Mr. Keller: Yes, that is true.

Mr. Garrigues: What will precipitate glue?

Mr. Keller: Tannic acid is most used. Alcohol, carbonate soda and alum will also do it.

Adjourned.

A. G. McKenna,
Secretary C. S.

Engineers' Society of Western Pennsylvania.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR T E OPINIONS OF ITS MEMBERS.

Pittsburg, Pa., April 28th, 1896.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held, for the first time, in the Library of the Society's new home, 410 Penn Ave., Pittsburg, on the evening of the above date.

President W. G. Wilkins called the meeting to order at half-past eight o'clock. There were seventy-five members and visitors present.

The minutes of the March meeting were read and approved.

Reporting for the Board of Direction the Secretary read the names of four applicants for membership approved by the Board and recommended for election.

Also that any member not in arrears for dues may obtain a key for the new house upon depositing with the Secretary one dollar, the amount to be refunded at any future time upon the return of the key.

The following named applicants were elected to membership: F. T. Aschman, Chemist; R. M. Atwater, Manufacturer; E. D. Frohman, Chemist; and E. A. Herring, Civil Engineer.

Mr. Gustave Kaufman, Chairman of the House Committee, stated that the Committee had succeeded in renting the two lower front rooms for fifty ($50) dollars per month and one third story room at five ($5.00) dollars per month; that there were other rooms on the third floor which they expected to rent, leaving to the use of the Society the entire second story, at a cost not exceeding the limit fixed, namely, nine hundred dollars per year.

He also reported that the rooms to be occupied by the Society had been painted and papered and handsomely furnished,

and that our effects had been transferred from the Carnegie Library Building to our new home without loss or damage.

Mr. Swensson, Treasurer of the "House Fund," reported that there were subscribed to this Fund $1050 and that $860 were in his hands.

The following resolutions were offered and acted upon affirmatively by the Society :

WHEREAS, in the proposed charter for cities of the second class it is provided that the Director of the Department of Public Works shall be elected by a direct vote at the city election, and

WHEREAS, the said charter also provides that the salary of the said Director of the Department of Public Works shall be four thousand ($4000) dollars per annum, therefore be it

Resolved, that it is the opinion of the Engineers' Society of Western Pennsylvania that the Director of same Department of Public Works should be an Engineer of established professional and administrative ability and that it is the opinion of the Society that it will be improbable to obtain such a Director by direct vote of the people, and it is further

Resolved, that the Society does not believe that an Engineer with the ability to design and supervise in a proper manner work of such magnitude as required by the city of Pittsburg can be secured for the salary proposed, and that same salary is entirely inadequate for the services required.

It was also voted that

WHEREAS, two years ago the Library Committee of Allegheny Council kindly tendered to us, jointly with other societies, the free use of rooms in the Carnegie Library in Allegheny, and

WHEREAS, we have enjoyed the privileges thus courteously tendered for the period of two years to the great advantage of the Society, therefore be it

Resolved, that this Society express to the said Library

Committee our hearty appreciation of the courtesy extended to us and our thanks for the privileges which we have enjoyed under it.

The Secretary was instructed to inform our representative in Congress of the action which the Society took sometime ago respecting the Metric System.

Mr. William Metcalf then gave a very interesting and instructive lecture upon Engineering methods and facilities during the past generation. He described the advantages of power machinery and the reduction in expenses resulting from its introduction; and indicated the improvements in transportation and communication during that period.

After the lecture the members and their friends repaired to the dining hall where refreshments were served and congratulations exchanged.

DANIEL CARHART,
Secretary.

CHEMICAL SECTION.

The regular monthly meeting of the Chemical Section of the Engineers' Society of Western Pennsylvania was held on Thursday evening, April 30th, 1896, at the Society Rooms, No. 410 Penn avenue, Pittsburg. The meeting was called to order at 8:30, P. M., twelve members and three visitors being present, J. M. Camp in the Chair.

The minutes of the last meeting were read and approved.

Upon motion of Dr. Stahl it was resolved that the regular monthly meeting of the Chemical Section be held on the Thursday evening following the third Tuesday of each month.

A discussion upon the advisability of holding informal social meetings on Saturday evenings followed, it being the sense of the Society that such meetings should be commenced at once.

The paper of the evening, entitled "Notes on Iron Ore Analysis," by M. Mixer was then read by M. McKenna, the Secretary, M. Mixer himself not being present.

NOTES ON IRON ORE ANALYSIS.

C. T. MIXER.

Inasmuch as our laboratory is situated in the heart of the Marquette iron mining district, the largest part of our work from this region consists in the analysis of iron ores.

Since the analytical treatment of these ores at the mines is attended with somewhat different conditions of time, etc , than when handled at the docks and furnaces, a few points on the methods we adopt would perhaps be in place, although I believe that most of them are already known to you.

Before making any mention of chemical methods, however, I wish to emphasize one point, which has already been "harped on" by others, but still is too often overlooked, viz :

insisting on the procuring of fair and impartial samples, before any analytical work is attempted.

So often it will occur that two chemists will differ to a marked degree in results on the same lot of ore, when, in reality, one or both of the samples was really worthless and several other samples of the same stope, pile, car or cargo would each and all vary beyond the limits, if taken with the same degree of carelessness, and ignorance of what is being dealt with.

This tends to put modern analytical methods in a bad light, when in reality they are not in the least at fault, if handled with a reasonable amount of care.

One can see in this and any other mining region numerous illustrations of the folly of careless sampling on the one hand, and per contra, the accuracy with which different classes of ores can be mixed to make a desired grade of ore when the sampling has been done systematically.

Another element that sometimes creeps in to the embarrassment of the chemist is the use of unsafe crushing and grinding utensils, several cases having come to our notice where chemists did not agree, they laying the blame on their chemical methods and manipulation, when, in reality one of them was reinforcing the iron and phosphorus in his sample by metallic particles from his crusher or plate.

Iron ore analysis in the vicinity of the mines, like iron analysis at the furnace, must be performed with the greatest speed possible, in order to be of any benefit, and consequently the chemists naturally adopt the rapid volumetric methods, preferring the quick results, that will be of some value, to those obtained by the longer methods, which though possibly a trifle more accurate, are too late to be of much service.

A practice which we always have adhered to as aiding to insure accuracy in these rapidly obtained results, is to constantly "run" samples of "standard" ores with our analyses, which being under precisely the same conditions, would imme-

diately show up any error of weight, solutions, manipulation, etc., and thus immediately put us on our guard.

With regard to the determination of metallic iron, we use the Zimmermann—Reinhardt method, described by us in the Journal of the American Chemical Society, May, 1895, which was then used by a few, and has since been adopted in many laboratories.

This is without a doubt the most rapid method for iron determination in existence, and with the beneficial aid of the stannous chloride in dissolving, determinations can be made in 5 minutes after weighing the sample.

Of course no such speed can be acquired in phosphorus determinations, owing to the fact that the ore must be dissolved in hydrochloric acid alone, which takes several times as long, and also because in most of the ores of the Marquette range, there is an appreciable quantity of insoluble phosphorus, which requires a fusion of the insoluble residue.

Our daily practice in phosphorus determination is to add a certain quantity of HCl (1:1) to the ores, which are then gently boiled until dissolved, the covers removed, a few drops of HNO_3 added and the solutions evaporated if necessary, when they are filtered into the precipitation flasks.

When the papers and residues are washed, they are dropped into their respective beakers, and passed to the person in charge of the Kellogg gasolene fusion burners.

He immediately puts three residues in as many platinum crucibles, burns off the papers, adds a measured quantity of sodium carbonate, and puts on the cover. In two or three minutes they are fused, when he tips the liquid mass on the side of the crucibles and puts on three more for similar treatment.

While the second lot are fusing he removes the fused cakes from each of the first crucibles, grinds it up in a porcelain mortar, rinses the crucible with HCl (1:1) into a shallow 4½ in. Royal Meissen evaporating dish, brushes in the powder from

the mortar, adds more acid if necessary, and puts dish on hot plate, for rapid evaporation of contents.

By following this system, several "insolubles" can be fused and evaporated to dryness in a very short time.

While this has been going on, the soluble phosphorus has been precipitated as phospho-molybdate, as follows:

As soon as the molybdate solution has been added, the contents of the flask are shaken for about a minute, by giving the flask a twisting motion in opposite directions, which can be done by a boy, after a little practice without fear of spilling any, doing away with the necessity of using a cork, and insuring a rapid settling of the precipitate.

We have always found that shaking with a cork was too violent, generally making the precipitate very fine grained, which does not settle so rapidly.

This is an important point in our mode of procedure, as we make a practice of siphoning off the clear liquid from the phospho-molybdate, which thus insures quicker filtration and washing, previous to titration.

When washed, the phospho-molybdate and paper are put back in the flask, the necessary amount of standard alkali added, a little water also, and a cork inserted, when the whole is given a violent shaking, which breaks up the filter paper into fine particles. The cork being rinsed off, the excess of alkali is titrated back with standard HNO_3, the difference between the alkali and acid being the percentage of phosphorus.

The "insolubles" which are redissolved in water and a few drops of HNO_3, are now filtered, precipitated and titrated, the figure, with the necessary correction for the soda being added to the soluble phosphorus result, the total phosphorus being thus obtained inside of two hours. As to the correction for soda just mentioned, it can either be obtained by running a blank soda determination, using the same amount as with the insoluble, or by having a standard "insoluble" as a guide.

In this connection it is well to add, that if platinum crucibles be kept smooth and bright on the outside, they will give much quicker fusions than if allowed to become dull and dented.

For alumina determinations, we have generally used Peter's method, as described by Blair, and have found it reliable, provided that two precautions be followed, viz: after adding the 3.3 cc. HCl, let solution stand a little, until it becomes a clear canary yellow color, before adding the other solutions. This will lessen the chance of iron being in the precipitate. The other chance of error is that the solution may not be boiled long enough to completely separate the phosphate of alumina. We find it well to do this boiling in a 16 oz. Erlenmeyer flask, which prevents any mechanical loss.

In the rapid determination of manganese, we use a method, which we are just publishing in the "Journal of the American Chemical Society,"* it having been read before the Franklin Institute, Philadelphia, Feb. 18th.

It is known as Särnström's Swedish method, and we believe it to be the most rapid method in existence for the determination of manganese in ores, it being possible to get results in a half hour.

We do not find it very reliable for very high ores, however, though of much service as an approximation.

The principle involved in the method is the precipitation of the iron by sodium carbonate in the hot solution, and direct titration with permanganate, the hydrate of iron present helping to collect the MnO_2, and leaving the clear supernatant solution for the discerning of the end reaction.

The main precautions to be observed are, not to have much excess of sodium carbonate, which would precipitate the manganese carbonate also, and to stir or shake the solution violently during titration.

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*April, '96.

Some time ago, in the determination of lime and magnesia in an ore containing about 5% manganese, we had difficulty in separating all the manganese with ferric-hydrate, by means of bromine and ammonia, and consequently the filtrate contained some manganese which in turn contaminated the magnesium pyro-phosphate, with some manganese pyro-phosphate.

In the particular case referred to, we were obliged to resort to ammonium sulphide, but in experimenting on it afterward, we recollected, that instead of using bromine water, we might use permanganate, as in the maganese method just mentioned, which would have the advantage of completely separating all the manganese, and at the same time indicate by the pink color when it is completed.

It was tried and found to work very successfully, and the final pink tinge was easily decomposed by boiling, before filtering.

The filtrate was clear, free from manganese, and the lime and magnesia were separated without further trouble.

I think this is a point that is sometimes overlooked, and that chemists sometimes unknowingly have their lime and magnesia preciptates contaminated with manganese.

We make a practice of redissolving the oxalate of lime in dil. H_2SO_4, and titrating hot with permanganate, which possesses the advantages of accuracy, neatness and rapidity.

Sulphur determination in an ore, when it occurs in small quantities, is by no means an easy determination.

We have generally found most satisfactory results from fusing the ore direct with sodium carbonate and nitrate, dissolving with water, filtering, acidifying, taking to dryness and finally precipitating, with barium chloride.

By this procedure, however, a blank determination must always be made, and the necessary correction made for the sulphur in soda.

LABORATORY OF MIXER & DUBOIS,
ISHPEMING, MICH., MARCH 1ST, 1896.

An informal discussion of the paper followed, after which the Society adjourned.

ALEX. G. MCKENNA,
Secretary, C. S.

Engineers' Society of Western Pennsylvania.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

Pittsburg, Pa., May 19, 1896.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in their lecture room, 410 Penn Avenue, Pittsburg, Pa., on Tuesday evening, May 19th, 1896. The meeting was called to order at 8:30 P. M., Mr. Emil Swensson, Vice-President, in the chair, and 25 members present.

The minutes of the last meeting were read and approved.

Reporting for the Board of Direction, the Secretary read the names of two applicants for membership approved by the Board and to be voted on at the next meeting.

Harry Etches, J. S. Cox, Jr., W. R. Marden and C. D. Marshall, applicants for membership, were then balloted for, Messrs. Bole and Lyons acting as tellers; 22 votes were cast for each, and they were therefore declared duly elected.

The Vice-President. As a member of the House Committee I might say here that we have received at this time a little over $900, but the bills coming in require very nearly the amount collected.

There are a few small matters about the house not yet attended to, but the House Committee will take care of them in due time.

It might be of interest to the Society to know that we are succeeding very well in renting the other portions of the house which we desired to rent. We now have an income of $65 per month from our tenants, and we will doubtless have $75 or $80 per month to count on before the first of June, so that you perceive we are on the safe side in our venture for a home of our own.

In the June notice the members of the Society will be advised that regarding the vacation months of July and August, the Board of Direction think it wise to have social meetings on the third Tuesday evenings in those two months, and I hope all the members will come out and enjoy themselves socially on those evenings.

Has any of the members anything to propose for the good of the Society?

Mr. Bole. Yes. The Program Committee sent out a circular some time ago desiring to get up something new, and it did not meet with that measure of success which could be desired. I do not know whether the members are too busy, or whether there is nothing going on worth telling. Certain it is that the responses have been few, and I would like very much indeed if we could interest the membership of the Society sufficiently to draw out volunteers and produce papers.

I think the Program Committee's work is the most responsible of any connected with the Society, and it is desired to get the people to produce papers which will be attractive and draw out a large attendance, but up to date I have been somewhat disappointed with the appearance of things.

I would like to know a person here present who knows how to draw out these people and get them to talk. I would like to have them give me some pointers. If we can find one fellow who knows some other fellow who has something to say, and who will send word to the committee—even if nothing more than that—the committee would gladly hunt up said fellow and get him to say it.

Most of the people who have been spoken to complain of being too busy, but the busy man is the very one we are most eager to listen to.

The program committee would like to enlist the assistance of the entire membership in this matter and make the Proceedings interesting and valuable.

It is true we have a good many illustrious members on our

roll, but they are keeping very quiet, and perhaps the younger members will have to be looked to, to take a more active part in the proceedings and, as I said before, I would like to know of any person here who knows how to get the people to volunteer papers and afford us assistance.

THE VICE-PRESIDENT. Is it not possible, Mr. Bole, that the Society has been looking too persistently to the "illustrious" members for papers, and that has deterred the younger members from making themselves heard?

I think it would be well to impress upon the younger members that a short paper—say two or three of them in an evening—anything to draw out discussions—is what we want. We have always been expecting and looking forward to some long paper; and something novel; something new. In my opinion it would be better if we did not expect so much in our papers as then we would probably get more of them.

MR. JOHNSON. Mr. President, I would like to offer a suggestion. One of the things of eminent value to our association as much as anything else, would be to make a receptacle for notes on matters coming under the observation of our members during the course of their professional work and that ordinarily do not get into the public records of any kind, and while each item in itself may seem unimportant, yet taken in connection with others which may be accumulated, becomes of great value, and many of our younger members, as well as the older ones, are constantly encountering just such things that ought to be made a matter of record in our Transactions.

I would offer that as a suggestion for the program committee to work on.

THE VICE PRESIDENT. Mr. Johnson's suggestion is a very valuable one. That will be a kind of note box. We usually hear of the proverbial "question box" but in this case it will be a sort of note box where the members can put their observations in a few words.

Suppose that the program committee should call for notes

or suggestions in a certain line or in a certain direction. Pittsburg is a part of the world in which you can take up lots of things in regard to steel. Electricity is another subject. Insulation is also a very good topic, and you can take up a great number of subjects about which to talk.

Mr. Bole. One trouble I think is the fact that very few men like to volunteer to do this sort of work; they like to be asked, and the committee would be very glad indeed to go to them and ask them for it if we only knew who the likely persons were.

It is generally regarded, I suppose, as an occasion where a man must distinguish himself and in getting up a paper he wishes time in which to prepare it; he does not like to go into something that will be criticised, but there may be those who have information and who would not object to giving it to the Society if properly approached and asked. They no doubt have friends, who know what the committee wants, and if they will let the committee know that such and such a member has something to say, we will do the asking.

The Vice President. How would it do in the monthly bulletins to ask members to send in their observations in a few words on a certain subject, and then have someone group them together? The program committee might formulate a question on which they wanted an answer and ask the Society as a whole to send in any information they might possess on the subject, and not make the question so that it requires a too voluminous answer. That is the way I understand Mr. Johnson's idea.

Something valuable, then, may be deduced from the grouping of these ideas. Then the members would furnish these little notes feeling that it would not devolve upon them to read a paper or stand a lengthy criticism thereon.

Is there any other suggestions of the Society in this or any other channel? Anything for the good of the Society?

I believe our last summer's boat excursion was a success. Has anyone any suggestion in regard to something this summer? It is about time to begin to think of it.

The next in order is Mr. Kirk's paper on good roads. Mr. Kirk has studied the subject a good deal and has gathered many figures in Europe, and no doubt we will all be pleased to hear what he has to say.

Mr. Arthur Kirk prefaced the reading of his paper entitled: "How to Get Better Roads," with the following remarks: "Mr. Chairman, I feel somewhat out of place in addressing this Society on a subject of this nature, and while I may not be able to say a great deal, still I might wish to 'hold a candle for some person to light his flambeau,' and if I can be the means of introducing the subject I will take great pleasure in doing so, as I feel that this Society should pay some attention to transportation.

"We have been spending millions and millions of dollars upon roads, on steamboats and railroads, which is utterly lost and worthless—a downright waste of wealth to the community in transportation, and we have got to awaken to the importance of the subject or else commerce and manufactures of the United States will drop behind the world.

"As far as I had the pleasure of seeing last summer they are far ahead of us in the way of improved water transportation in Europe, and unless we take hold of the matter we will fall behind."

THE ADVANTAGES OF GOOD ROADS AND HOW TO GET THEM.

I will first call your attention to a few facts connected with the present road law.

When, about six years ago, I was appointed by the Engineers' Society of Western Pennsylvania to act on a committee to prepare a better road law, I had no idea of the number of surprises that awaited me.

I at once set to work inquiring into facts connected with the present road laws, and I became so interested in the subject that even after your committee had reported I kept on in-

fending the State in *War or Suppressing Insurrection.*" The right to make military roads at Government expense has been a Government power ever since the days of Julius Cæsar, and by doing so the Romans conquered nearly the then known world. Napoleon made Military roads all over France, which has made France the best cultivated country in the world to-day.

The United States made a grand Military road, called the National Turnpike, which did good service in the early settlement of the then far West. I merely mention the above historic facts to show that it is the duty of the State to pass the following proposed law. Because it is well known that the United States troops repeatedly suffered great hardships during the Secession War, for want of good roads, notably "the Burnside stick in the Mud," and we all remember how the second detachment of Philadelphia troops was stopped at Altoona in 1877, and prevented by bad roads and an Altoona mob from coming to the relief of the first detachment of Philadelphia troops then in great danger of total annihilation by an uncontrollable mob in Pittsburg.

As Washington, in his valedictory address said, "In time of Peace prepare for War," I therefore say we should as soon as possible construct a grand system of Military Highways, the very existence of which will be a State protection, for if the Altoona mob had known the Philadelphia troops could easily reach Pittsburg by a good road, they would not have been so ready to tear up the Pennsylvania Railroad.

I further remark it will be better and cheaper to make an entire new system of roads, than to attempt to change or interfere with the present system of roads. *Because many of the present bad roads have been badly located* after long and expensive ligitation, which would surely be repeated if an attempt was made to change them, besides the privilege of working out taxes is so highly prized by many farmers. This plan of making military highways will come in as a totally different system, without disturbing the present system, and as I am sure it can

be used to make such extra good roads that after farmers see what good roads are they will petition to have Military roads made every 20 miles apart, and then every 10 miles apart, and then every five miles apart. And whoever lives to see that time will find Pennsylvania the best country in the world to live in.

The reason why I propose at first to make the Military Highways 40 miles apart is, at that distance apart, every county in the State will be reached by a Military Highway, and thus derive some benefit from the money in circulation for labor, etc.

The constitution of Pennsylvania says: "The Secretary of Internal Affairs shall perform all the duties heretofore performed by the Surveyor General, and all other duties the Legislature may direct." I therefore recommend he shall be Chief of Military Highway department, same as we have a Postmaster General over the whole United States, and if we have Military Highway department as well administered as the Postoffice department, we will soon have little to complain of about highways. Because,

1st. If enacted the bonds will draw interest from the date of issue, and will be made as low as fifty dollars each, and when registered they will be of no use to any one except the owner or legal representative. There will, therefore, be no danger of having such bonds stolen, for if stolen they would be no use to the thief. They will thus be a safe investment for idle money.

2d. If enacted many millions of dollars now hoarded away and doing no good, but a dread of losing to their owner, will then be put into circulation in every county of the State at the same time, and thus give employment to many thousands of men now idle.

3d. When enacted, and such roads made with a double-track street railroad on every mile of them, carrying farm produce to market for one dollar per ton, where it now

costs from five to ten dollars a ton, and passengers in comfortable cars for one cent per mile, at the rate of 10 to 15 miles per hour, where now it is impossble to travel by any conveyance. Then much land now unsalable at any price will be in great demand at high prices all along such roads.

4th. If such roads are made to a three per cent. grade through hilly parts, it will, of course, require much side cutting on hill sides, and that will, no doubt, uncover much valuable minerals now unknown, but when known will be worth far more than the cost of grading such a road.

5th. When such roads are finished, every 40 miles apart, they will be found to be of such advantage that they will be demanded to be made every 20 miles apart, and then every 10 miles, and then every 5 miles apart, and when that is reached Pennsylvania will look like a large pleasure garden, and the best place in the world for farmers, and the 20 millions of dollars now annually sent West for farm produce, will then be paid to our own farmers, and kept to circulate among our own mechanics.

MILITARY ROAD LAW.

Sec. 1. Be it enacted by the Senate and House of Representatives of Pennsylvania, and it is hereby enacted by the authority of the same:

Sec. 2. That on and after the passage of this act it shall be the duty of the Secretary of Internal affairs to take charge of all matters relating to the construction and maintenance and management of all Military Highways throughout the State of Pennsylvania.

Sec. 3. The Secretary of Internal Affairs shall construct a good Military Highway every 40 miles apart, across the State of Pennsylvania, at right angles with the State line, and as nearly parallel with each other as the topography will permit, and shall construct Military Highways every 40 miles apart, lengthwise of the State, as nearly parallel to each other as the

topography will permit, 40 to 60 feet wide, at the discretion of the Secretary of Internal Affairs.

Sec. 4. The Secretary of Internal Affairs shall have no power to make Military Highways through cities or boroughs or public or private grave yards, without consent. But if the streets of a city or borough are, in his judgment, not suitable for a Military Highway, as required by this act, he shall locate the Military Highway around that city or borough on ground beyond the boundaries of said borough or city, but as nearly parallel and 40 miles apart from other Military Highways as the circumstances will permit.

Sec. 5. The Secretary of Internal Affairs shall as soon as the Military Highway is completed, place a milestone of suitable material at the end of each mile, suitably marked, giving distance to and from prominent places along the Military Highway, and see that the milestones are maintained in good order.

Sec. 6. The Secretary of Internal Affairs shall, as soon as possible, ascertain the total cost when finished, including interest, of each Military Highway, in sections, from place to place, and shall then give 20 days' notice of time and place where (using the total cost of said section as an up-set price). He will sell at public auction to the highest and best bidder over the up-set price, the right to lay and use a double-track street railway on each section, and use the same for transporting freight or passengers on it, on such section as may be advisable, for 20 years, under such rules and regulations as the Secretary of Internal Affairs may from time to time adopt, and at the expiration of the first 20 years' term shall readvertise and sell as above every 20 years.

Sec. 7. All monies received from above sales, or from any other source relating to Military Highways, shall be paid to the State Treasurer direct and shall be kept by him separate and distinct from all other money in his care, and only paid out by order of Secretary of Internal Affairs, as provided for by this act.

Sec. 8. The Secretary of Internal affairs shall hereby have full authority to make, publish and enforce rules for the proper care and use of all Military Highways, providing such rules or use of Military Highways do not interfere with the use of said Military Highway when needed by military on duty.

Sec. 9. The Secretary of Internal Affairs shall, as soon as practical after the passage of this act, open and maintain an office in Harrisburg, for the transaction of all business relating to Military Highways. He shall furnish said office with all needed appliances, including books, surveyors and draughtsman instruments, furniture, etc.

Sec. 10. All expenses connected with the opening or maintaining said office in Harrisburg, or for purchase of tools of labor or material, or any expense incurred for making or maintaining all Military Highways within Pennsylvania shall be paid by check of the Secretary of Internal Affairs and countersigned by his chief clerk drawn on the State Treasurer, and shall be paid by him out of money in the Treasury provided for by this act and not otherwise appropriated; and shall state on its face when drawn and have receipted bill of item attached and date when paid and all such checks with bills attached shall be retained for five years by the Treasurer as vouchers for so much money. He shall purchase all tools and materials.

Sec. 11. Secretary of Internal Affairs shall purchase at best advantage to the State, all tools, machinery, or appliances required for carrying out the object of this act, and shall annually, in January of each year, set apart a sufficient sum of money for this use out of the money hereafter provided for by the sale of bonds or other income.

Sec. 12. The Secretary of Internal Affairs shall cause to be located above described Military Highways on the best possible location without regard to cost of land, and make them 40 to 60 feet wide on surface, well drained, and no part of any Military Highways shall be over three per cent. grade when finished; and he shall use all proper means to maintain all Military Highways in best possible condition.

Sec. 13. In making the above Military Highways, the Secretary of Internal Affairs shall claim for the State of Pennsylvania the right to use without compensation, the six acres of land originally reserved to the State "for the purpose of making roads when needed," where the said allowance for roads has not been previously used for making public roads and are needed for making Military Highways.

Sec. 14. Secretary of Internal Affairs shall appoint a Court of Appeals, and fill all vacancies in said Court, whose duty it shall be to adjudge all claims for damage by Military Highways under such rules as said Court may adopt.

Sec. 15. Said Court of Appeals shall consist of three competent persons, of which any two may constitute a quorum, at least one of which shall have at least five years' experience as a civil engineer. The Secretary of Internal Affairs shall designate one to be President, one Vice-President and one Secretary, and all shall receive salaries and traveling expenses, as the Secretary of Internal Affairs may direct, and all may hold office during pleasure of Secretary of Internal Affairs, and shall, before entering upon the duties of office, take the usual oath of office.

Sec. 16. All claims for damages by owners or lessee of land by reason of location of Military Highway shall be presented to Secretary of Internal Affairs within three years after the work complained of has been finished, and shall be accompanied by a certificate from the Treasurer, showing complainant has paid into the Treasury twenty-five ($25) dollars to the credit of Military Highways. The Secretary of Internal Affairs shall then submit the same to the Court of Appeals, shall appoint a time within two years where they will visit and inspect the ground, and shall carefully inquire into all facts connected with the case and after hearing all offered sworn testimony, shall take into consideration all facts relating to damages and benefits, shall credit all damages and debit all benefits, and render judgment for balance, if any, as strict justice may require.

Sec. 17. The time of the Court of Appeals devoted to any one case to hear a claimant, either by person or by attorney, and to hear the Secretary of Internal Affairs, either in person or by attorney, and to decide the case and record judgment shall not exceed two days on any one case. The Secretary shall make two copies of minutes of trial and forward one to Secretary of Internal Affairs within ten days and retain one copy.

Sec. 18. The Court of Appeals shall hear both sides and decide the case justly, awarding damages and assessing benefits, and strike out the balance on either side, which, if not paid within six months, shall then be collected by due process of law, as sums of like amount are collectable by law.

Sec. 19. The Secretary of Internal Affairs may, after five years, after work on any part of Military Highway has been finished, present his claim for benefits to Court of Appraisement as above described to determine the appraisable increased value of benefits the construction of a Military Highway has been to any land abutting on either side of said Military Highways, and within two miles of said Military Highway on either side of it, and said appraised increased value shall be a lien on said property to be collected as Secretary of Internal Affairs may direct.

Sec. 20. Every witness examined on an appeal case shall be entitled to receive three ($3) dollars per day to be paid by claimant.

Sec. 21. Any claim for damages as above may appeal from first decision, and, if he hands a receipt from State Treasurer to Secretary of Internal Affairs showing he has paid to State Treasurer twenty-five ($25) to the credit of the Military Highway fund in addition to former twenty-five dollars, may require the Secretary of Internal Affairs to appoint a special Court of Appeals to sit within forty (40) days to try the case over again, who shall give a fair and impartial hearing to both sides as before; and their decision in the case shall be

final before above Court, but the appellant may on payment of fifty dollars appeal to county courts as now by law provided in road appeals.

Sec. 22. It shall be the duty of Secretary of Internal Affairs to appoint a court of three competent civil engineers as his counselors in all matters relating to Military Highways, and to examine all applicants for positions to act as civil engineers on Military Highways. Said court shall rigidly examine, under such rules as they may adopt, all applicants for positions as civil engineers in charge of construction of Military Highways, and no one shall be appointed as civil engineer on Military Highways who has not been approved by at least a majority of said court. When an applicant has passed a satisfactory examination, the said applicant shall be given an approving diploma, and only engineers with such diploma may be employed by the Secretary of Internal Affairs in the construction of Military Highways.

Sec. 23. The above court shall also adopt rules for locating all Military Highways with best engineering skill; shall appoint one of the above approved civil engineers in charge of locating each Military Highway provided for by this act, and before final location, at least one of the three members of Engineers' Court, or an experienced civil engineer as deputy, shall personally go over the route and location of each and every part of proposed location, and carefully select the best location, which selection shall be final and shall be so reported to the Board with the necessary drawings.

Sec. 24. The Secretary of Internal Affairs shall notify the State Treasurer before the last day of November of each year, how much money will be required during the following year for paying all expenses of making and maintaining all Military Highways during the following year. This sum shall not exceed twelve million dollars in any one year.

Sec. 25. After receipt of such notice the State Treasurer shall give at least ten (10) days' notice of the time and place

where he will, on the first Tuesday of each month, sell at public auction to the highest bidder, Pennsylvania Military Highway bonds to the amount of $——— monthly during the year, until the amount required by the Secretary of Internal Affairs for constructing and maintaining the Military Highway has all been sold as above directed.

Sec. 26. Such bonds shall be known as Pennsylvania Military Highway bonds and have twenty years to run, from date of issue, at the option of the State, at three per cent. interest per annum.

Sec. 27. No such bonds shall be for larger amounts than five hundred ($500) dollars each, and none for less than fifty ($50) dollars each, and all made payable, principal and interest, at State Treasury in Harrisburg.

Sec. 28. All such bonds shall be either registered or coupon bonds as the State Treasurer may direct.

Sec. 29. All proceeds of sale of Pennsylvania Military Highway bonds shall be paid to the State Treasurer, and by him kept separate from all other monies in his care, and only paid out as directed by this act.

Sec. 30. Any person connected with Military Highway business who has acted dishonestly in any financial transaction whereby the State loses to the amount of five ($5) dollars or over, such as dishonest making of contracts, dishonest inspection of work, dishonest purchase of tools or material, fraud in pay rolls, or wrong use of money in any way, such a person may be indicted as guilty of misdemeanor, upon conviction thereof shall be sentenced to imprisonment not less than three months or more than five years and pay a fine of five hundred ($500) dollars, one-fourth of which shall go to the informer and the three-fourths of said fine shall be paid to the State Treasurer and placed to the credit of Military Highways.

Sec. 31. The Secretary of Internal Affairs shall annually, on or before the first day of December of each year, notify the State Treasurer how much money will be required

during the following year to pay construction and interest on bonds and principal of bonds maturing during the next year. On receipt of such notice State Treasurer shall, as soon as practicable, apportion said sum to each county in proportion to the acreage of each county, and serve notice on the county commissioners of each county to include in their next annual assessments of taxes a sufficient sum, not to exceed two mills in any one year, as a Military Highway tax to pay their county quota of said tax, to be levied on all taxable property as per county appraisement within each county, and to be paid same as all other county taxes are paid in each county, and forwarded by the County Treasurer to the State Treasurer monthly and credited to the Military Highway account.

Remarks.—The money required by this section will all be more than refunded to State Treasury by premiums above cost as per Sec. 6, and increased valuation as per Sec. 19.

Sec. 32.—All properly appointed engineers under this act, and his assistants, shall have full authority to enter upon any property to make preliminary or permanent surveys, and shall be held personally responsible for all unnecessary damage done while so locating.

Section 33. The Secretary of Internal Affairs shall cause all proper plans and specifications to be made for all work to be done in making or taking care of all Military Highways, which shall specify time when work on contract shall begin, and time when contract shall be finished, and terms of payment under such penalties as Secretary of Internal Affairs may direct, and terms of forfeiture of contract for cause.

Sec. 34. Secretary of Internal Affairs shall give at least twenty days' public notice of time and place where bids will be publicly opened for contract work, and award publicly made to lowest and best bidder on terms and plans prepared by the Secretary of Internal Affairs.

DISCUSSION.

THE VICE PRESIDENT. Gentlemen, this is a new addition to the road law literature to which I hope you will have something to add. It is very well thought out, but I suppose there are some who may have different views. Mr. Johnson, have you anything to offer?

MR. JOHNSTON. I would like to ask Mr. Kirk for a little information. In section No. 13 he refers to six acres of land originally reserved to the State for the purpose of making roads when needed. That is something in the road laws of the State entirely new to me, and I would like an explanation.

MR. KIRK. I am not surprised that you should not know that; not one in a hundred knows that. I find, however, that it is a fact that the state owns six of every 100 acres in the State for the purpose of making roads. It came about in this way: When William Penn got the grant from the English king on the land which is now known as "Pennsylvania," he was anxious to encourage immigrants to settle on his possessions in America, and published a descripition of it in which was a clause saying that he would make all public roads between cities. That seemed to be an attractive feature to encourage immigration but when the people came here there were no cities to make roads between. There being many difficulties in the way it was afterwards compromised on this basis, that when a property sold an 100 acres, pay was exacted for only 94 acres, these 6 acres to be used for making roads wherever needed. That seemed to be a very peculiar arrangement but it stands to-day, because a case was brought up in 1837 in Lancaster County before the Supreme Court and they decided that it was still pending, and that the State still owns six acres of every 100 acres of land for road purposes.

Wherever this is not used you have the right to take those six acres of land for the purpose of making roads without compensation.

I consulted the books in the library at Harrisburg in this State and it is correct without doubt.

THE VICE PRESIDENT. It occurs to me that this law will be pretty hard to get through in any State in the Union, because it has somewhat of a taste of European road laws, and is, I think, a little positive.

The people in each county or in each township have under this law no chance to have a say in the matter. It is difficult to introduce anything here in which the common every day man would have nothing to say on the subject.

MR. KIRK. As to the possibility of getting the law passed, of course there are difficulties to be expected and encountered in every movement for any great benefit, but the country is getting awake, and I am astonished to find how many men are becoming in favor of this now.

Take a farmer for instance, who has to haul his produce 20 or 25 miles to market; well, he cannot haul on an average more than about a ton; that is considered to be above the average load of a farmer. Now it takes him all day to drive (say he lives in Glade Mills) into town and sell his produce and it takes him all the next day to drive back again, and when he gets back both himself and the team are tired out worse than if they had staid at home on the farm and worked.

Now you cannot hire a team for less than $3.50 per day and here is $7.00 of expenses that farmer has to stand to get one ton of produce to market.

Now there is $7.00 to be taken out of the proceeds of of that ton of farm produce, which cuts down the profit considerably.

Is it any wonder that the boys and girls do not stay on the farm?

THE VICE PRESIDENT. Mr. Kirk, you propose a 3 per cent. grade, isn't that rather low for some sections of this State when the roads are made so nearly parallel as you intend them to be?

MR. KIRK. Well, about three years ago I traveled over a hundred miles of the old national turnpike, and that road is made on the old theory that it is better to have a hill once in a while for a horse to go down so that he will get rested the better to go up the other side. I cannot say what the maximum percentage of grade on that road is, but it is far too steep for any heavy load to be hauled up.

It is quite possible to have the grade 3 per cent. I found the master of roads in France, in Switzerland and the headman in Sweden all in favor of low grades.

I was living on a farm in Butler County 50 years ago and when we went to market we would like to take five more bags, but we would have to go up Deer Creek hill. I do not know what they built roads over such hills for unless they thought that the steeper the grade the better the chance for the horse to get rested. Just calculate what that steep grade has cost in 50 years and is costing. I would consider a civil engineer pretty "uncivil" who could not make a 3 per cent. grade.

A MEMBER. Referring to section No. 13 in which you speak of six acres of land, suppose you first paid for land acre for acre and the State claimed the land then?

MR. KIRK. A man cannot buy or own what the seller has no right to sell. As an illustration of the importance of those feudal rights many years ago I will mention the spot in Allegheny City where you now see those nice blocks in Market square; there is a clause in the deed to the location of the City of Allegheny that these inside lots in Market Square outside lots called the common or the pasturage for the owners of outside lots subject to the feudal right of one acre every seven years if demanded by the Penn family, and these 100 acres are subject to the feudal right to be used for road purposes if required.

THE VICE PRESIDENT. I notice you suggest quite a number of courts; you have no less than four different ones in this road law, whose tenure of office shall continue only as long as

the Secretary of Internal Affairs may see fit. It seems to me that there ought to be some sort of civil service clause in this law as regards time of service. It seems to me, also, that the personnel of these courts would change too often for the good of a scheme as extensive as this.

MR. KIRK. That was one of the hardest things I had to contend with, as I know there is always a swarm of hungry politicians ready for anything that can be had, but I thought it would be better to have too many than too few officers.

MR. JOHNSON. There is a point here directly connected with the question of roads, and that is the accounting for expenses. The latter part of section No. 10 provides that all such checks with bills attached shall be retained for five years by the Treasurer as vouchers for so much money. Is it the intention that the Treasurer may at his discretion destroy those vouchers after five years?

MR. KIRK. Well, I think that five years is the limit of accounts collected at law, and they are of no use after that.

MR. JOHNSON. You would destroy the records. I think all vouchers for the payment of money should be retained indefinitely.

Suppose our Auditing Committee now looking over the city's books should run up against a legal destruction of the records; they would be at a loss to know what to do.

MR. KIRK. In case of the Auditing Committee on the city's books, it is not often that they are compelled to go back over five years.

MR. JOHNSON. But we should be able to know what has been done; I would not fix any time when they might be destroyed; I would not make it lawful to destroy them at all.

A MEMBER. I would like to ask what kind of roads are to be constructed, and is the detail of the road bed to be fixed?

MR. KIRK. Well, no. That is a matter of very great importance, but in some places in Pennsylvania it would be a very difficult matter to settle upon. In Allegheny County I do

not know a single place, unless it be at the small quarry out the Panhandle Railroad, where you could get good, hard stone for the bed of a road.

Then it is very important that the road bed should be properly made, and this can only be done by procuring good, hard stone in some way or another.

Here is another plan: Several years ago vitrified brick were used very extensively, and this being an age of improvement we don't know what kind of good material may come up. New things may be discovered which we do not now know anything about, and you could not fix a rule now to go by in the future. I think it would be better to leave it to the good judgment of the Secretary of Internal Affairs.

The head man of the French roads (I cannot now recall his name) said: "That is the best road law in the world." The question of transportation of stone from the Ligonier Valley, or of blue stone up the Connellsville Railroad, to say Crawford County, would be impossible, but in every place we could find clay to make vitrified brick and so save that transportation.

You will observe that after the road has been completed—the grading finished—and ready for stone, then the right is to be sold, including the cost of stoning, whatever it may be, and then the material could be transported on a temporary track by the electric company, even though it has to be hauled by horses, and on account of the transportation of so much material considerable revenue would be derived and would be a great inducement for the company to bid for the 20-year lease.

I consulted the head man of the Allegheny Electric Co. on this subject, and he said there would be no trouble at all to sell those roads at a large premium.

Mr. Johnson. Your remarks suggest one idea that has been running through my mind all the evening. Mr. Kirk in his preliminary paper, before he began reading his law, gives a good deal of other interesting and valuable matter.

His discussion since and his answers to questions in the discussion shows that he has at command a large fund of other information, and I simply want to say that I regret that he did not enlarge somewhat upon that preliminary paper. The first thing to be accomplished before we get any law in Pennsylvania is to get acquainted with the advantages and benefits which good roads will bring.

Mr. Kirk. Well I might say I could have lengthened it out a great deal, but I thought I might tire your patience; but if you want more of it I will gladly take it up again at the next meeting. Take these copies home with you and study them. There is no more important subject to Pennsylvania to-day than that of transportation. It is astonishing to think that when I was a weaver 21 years old 8 or 10 yards of cloth was a good day's work, and while I was at the Exposition at Chicago, I saw one girl attending to three looms and each making 50 yards to each loom and better cloth than I made by hand. And take the shoemaker, more shoes can now be made in a day by machinery than 100 men would do in the old fashioned way. So the rush goes on in the same fearful way, and in order to keep pace with the advance we must have better facilities for the transportation of raw material.

If we had adequate means of keeping pace with the advance in manufactures in the way of transportation, our products would beat anything in the world. Why, I saw them transporting coal in port at Hamburg from the vessel bringing it from Wales. One man pushed 40 tons of coal 4 miles and brought the empty car back in the afternoon ; thus he delivered 80 tons of coal per day to a vessel 4 miles away, and that for one dollar. I wish we could do that in Pennsylvania. We could not compete with that at all.

As to our water transportation, our rivers ; there are no such rivers in the world as the Allegheny, Monongahela and Youghiogheny for mineral and natural gas resources. There is nothing like the Allegheny for natural gas. But while we

have all these natural resources at our door we are allowing manufacturers to slip away from us. Why, Duluth and Cleveland are now making more steel than we are in Pittsburg, and we have better advantages in many respects. It is worth while just to stop and think of the number of industries that have left this city already. All this takes employment away, and tends to depreciate property in Pittsburg.

Adjourned.

DANIEL CARHART,
Secretary.

MEETING OF THE CHEMICAL SECTION.

The regular monthly meeting of the Chemical Section of the Engineers' Society of Western Pennsylvania was held on Thursday evening, May 21st, at the Society rooms, 410 Penn Avenue, Pittsburg. The meeting was called to order at 8.15 P. M., nine members and one visitor being present, J. M. Camp in the chair. The minutes of the last meeting were read and approved.

Dr. F. C. Phillips, for the Committee on Methods, reported that a number of papers were now with the printer ready for publication.

On motion of Mr. McKenna it was resolved that all the remaining papers on Methods at present received should be published in the May and June Proceedings if possible.

Mr. W. E. Garrigues then read his second paper on Notes on Analytical Methods.

THE RAPID DETERMINATION OF POTASH IN MANURES.

Laboratory Notes on Analytical Methods.

(Second paper.)

This paper, the second of a series under the same title, will include a consideration of the following subjects from an analytical point of view:

1. Potash.
2. Manganese.
3. Sulphur.
4. Formic aldehyd,
5. Calcium.

Manures are specified because the content of potash is seldom or never required without that of soda also in anything except manures, and this process is applicable to potash only.

The most rapid and probably best method now in common use for this purpose is that adopted by the Association of Official Agricultural Chemists, depending upon the isolation of the alkali sulphates by precipitating iron, aluminum, calcium magnesium and most of the phosphoric acid with ammonia and ammonium oxalate, evaporating the filtrate and igniting the residue with sulphuric acid to destroy organic matter and expel ammonia. Resolution in water and filtering followed by evaporating with platinum chloride as usual, using a solution of ammonium chloride for washing out the sodium sulphate.

The advantages of the method now proposed scarcely need emphasis. First of all the substance is ignited, thus getting rid of organic matter and ammonia salts; the ash is dissolved in hydrochloric acid and iron aluminum, calcium and magnesium precipitated with sodium carbonate, evaporating the filtrate at once with platinum chloride and washing out sodium sulphate as before with ammonium chloride solution. It is not at all necessary to add the platinum chloride in excess of the soda present as the double chloride of sodium and platinum is equally serviceable in precipitating potash. If therefore enough be added to give a yellow alcoholic filtrate an excess is assured. The whole process does not consume more than two hours. The details of the method follow: 10 grams weighed into a platinum dish are ignited to a clean ash; 10 cc. strong hydrochloric acid added boiled five minutes, then 50 cc. water and boiled 10 minutes. Rinse into a 250 cc. flask, add a few drops phenolphthalein solution and saturated sodium carbonate until permanent red color is produced. Make up to mark, filter and aliquot 25 cc. (This can be done at once without cooling or settling.) Acidulate slightly with HCl and evaporate with platinum chloride as usual. Filter on a Gouch crucible, fitted with a single disk of filter paper and wash by decantation with .848 sp. gr. alcohol 5 times; then twice with 10 cc. each time of ammonium chloride solution, repassing a third 10 cc. 5 times. Wash again 5 times with alcohol of the same

strength as before, dry at 100° C and weigh. (The formula for the ammonium chloride wash is given in the first part of this paper, Vol. xi, pp. 340.)

The use of soda salts as a precipitant in potash determinations has likely escaped notice from the fact before mentioned that it is in so few substances that potash only is required. The large amount of soda introduced of course remains with platinum preciptate of potash, as chloride sulphate and phosphate, all of which, however, dissolve immediately in the ammonium chloride solution causing no difficulty whatever.

No account is taken of the volume of the precipitated carbonate and phosphate in the flask when aliquoting because it has been shown by several experimenters, including the writer, that all the precipitates thrown down during any process of potash determination, occlude more or less potash and the error thus unavoidably introduced is scarcely counterbalanced by the slightly additional amount of solution pipetted off.

As the potash in fertilizers is frequently added in the form of chloride, some experiments were made to determine the possibility of loss of this salt during the ignition. These have as yet not been very thorough and I am unwilling to make the positive statement that no loss can be occasioned, but in a few attempts none whatever was found. Thus the following figures were obtained by this and the Official Lindo-Glodding method respectively.

L. G.	Na_2Co_3
1—1.74	1.68
2—1.99	2.06
3—1.78	1.82
4—2.64	2.72

These samples all had the potash present as chloride. No precautions in igniting were observed, the full flame of a good Bunsen being employed in each case. The explanation of the fact that the KCl was not volatilized in the above experiments will perhaps lie in the free sulphuric or phosphoric acid present

in most commercial fertilizers, and an additional precaution would of course be the addition of sulphuric acid before ignition. This however is more tedious, necessitates the grinding of the ash and is hard on the platinum.

In fertilizers containing potash only as sulphate the writer can give assurance of the absolute reliability of the method here described ; it having been tested extensively on mixtures of known composition and against the generally accepted Lindo-Gladding process.

The Error in Weighing Manganese as Mn_3O_4.

The writer was recently induced by a difference of opinion on the subject between a member of this Society and himself to ascertain the limits of error possible by weighing small precipitates of Mn_3O_4 and calculating to Mn. Accordingly a solution of the sulphate was made and its actual value determined by several precipitations as phosphate. 25 cc. was found to contain .1232 grains Mn.

Six other portions of 25 cc. each were then precipitated with 5 grams sodium acetate and 25 cc. bromine water, the filters and contents being ignited over a low flame to complete charring of the paper, gradually raising the heat and finishing with a blast. Using the factor .7205 for converting the oxid thus obtained, to the metal, the following numbers were found:

	.1270
	.1280
	.1285
	.1295
	.1295
	.1309
Average,	.1289

Showing no very serious error in the case of low percentages such as exist in pig iron and common steel.

The results are sufficiently concordant to suggest the factor .6886 instead of .7205. Using the former on these same precipitates we have:

.1214
.1224
.1228
.1237
.1237
.1251

On Some Evolution Methods for Sulphur in Iron and Steel.

By utilizing the property of caustic alkali to effectually check a current of H_2S, followed by oxidation after washing out the single test tube necessary for absorbing the gas, a clean and inoffensive solution is rapidly prepared for final precipitation.

The evolution is conducted exactly as for the iodine titration except that 10 grams of the drillings are used in place of 5. The absorbing liquid is 10 per cent. caustic soda, and 65 cc. are used for a determination, being contained in a single test-tube, to the bottom of which the delivery tube dips.

50 cc. of water are poured onto the drillings in the flask, followed by 40 cc. strong HCl, the heat of the combination starting a brisk evolution of gas at once. After complete solution of the metal and boiling, the test-tube is rinsed into a beaker, 10 cc. 5 per cent. potassium permanganate added and heated to boiling; this completes the oxidation. Twenty cc. strong hydrochloric acid is next poured in, followed by 15 cc. saturated oxalic acid, which leaves the liquid clear and colorless. Neutralize with ammonia, just clearing with hydrochloric, and precipitate boiling with barium chloride. The neutralizing seems to be necessary.

Bromine was tried before permanganate, but gave indication of lower results. The possibility of correcting this error

seems assured, but bromide is sufficiently unpleasant to let alone when something else will answer equally well.

The figures obtained on a sample of steel by the above two methods of oxidation, the evolution being identical, and also by the aqua regia method, follow:

Aqua Regia.	Bromine.	$K_2Mn_2O_8$
.048	1 .042	.046
.049	1 .042	.046
	2 .045	.047
	3 .047	.048
	3 .047	.049

The bromine results need an explanation.

No. 1 was oxidized as follows: Bromine water added to alkaline solution, heated to boiling, acidified and bromide boiled off.

No. 2 ditto, except alkaline solution boiled one-half hour after addition of bromine.

No. 3 ditto, boiled one hour.

The one objection to alkaline oxidation methods is the practical impossibility of obtaining caustic soda free from S in some form. This necessitates subtracting a "blank." Some attempts to get rid of the sulphur were only partly successful; using a saturated solution as a basis (obtained in exactly the same manner as was described for getting rid of carbonate in the first part of this paper), reduced the blank from 16 to 7.7 mgms. Adding excess of $BaCl_2$ and letting stand two days reduced it to only 12.1 mgms. The saturation process is recommended, the clear liquid being diluted to 15° B., at which density it contains about 10 per cent. NaOH.

The above-described process should be especially advantageous in the accurate analysis of pig iron, where the sulphur contents of the residue is to be determined. In that case there is certainly no advantage in titrating the evolved sulphur with iodine and then working the residue gravimetrically; instead the two are combined and one precipitation only made.

As to the iodine titration of the evolved sulphur arrested by caustic alkali, some experiments warrant the conclusion that the method is a strictly empirical one, not depending upon complete reactions like the gravimetric results.

In other words the equation,

$$H_2S + I_2 = 2HI + S,$$

in which 253.7 I are equivalent to 32 S cannot be assumed as a basis for calculating the sulphur value of an iodine solution of known strength. The results thus obtained, when caustic alkali is used, are always too low.

A solution standardized empirically, i. e., against a steel of known sulphur content, will contain less iodine than one standardized by calculating from its oxidizing power. As the equation before stated is the simplest which can be assumed to take place between H_2S and I, the least possible amount of I as compared to S entering into it, the choice of two explanations remains to account for the discrepancy.

1. The sulphur is not all evolved from the steel of H_2S, and

2. The H_2S is partly oxidized to H_2SO_4 in the alkaline solution during evolution.

Explanation No. 1 must be dropped for the reason that when cadmium chloride is used the whole of the sulphur evolved precipitates as cadmium sulphide, and again becomes H_2S on acidifying, as shown by its requiring the full theoretic quota of I. The suggestion of partial oxidation alone remains then, to account for the shortage, it having been proved by direct experiment that no H_2S escapes during titration. The means of doing this was to add at once an excess of iodine and then back titrating with sodium thiosulphate.

Following are results obtained on the same sample of steel mentioned before, and shown to contain about .048 sulphur. The absorption in caustic alkali was carried out in precisely the same manner as were the gravimetric analyses previously recorded:

Caustic Soda Absorption.		Cadmium Chloride.
Direct with iodine.	Back with $Na_2S_2O_3$	
.038	.039	.047
.039	.039	.047
.042	.041	.049

Similar results were obtained by the sodium hydrate method on standard samples kindly furnished by Mr. Camp and Mr. Handy, all of which were sufficiently concordant to have been apparently correct had any one of the samples been used for standard titrating solution instead of taking its theoretic value. They did not, however, agree among themselves quite as well as either the gravimetric results or those obtained volumetrically with cadmium chlorid as an absorbent, the series above given being rather better than the average. Both absorbents gave a blank titration equivalent to .002 which was substracted. To sum up: an iodin solution cannot be used indiscriminately for titrating sulphur evolved into caustic alkali and cadmium chlorid. The former requires a standard steel as a basis of calculating, all evolutions being made as nearly as possible under the same conditions, while the latter can be interperted from the theoretic value of the iodin solution, the results agreeing more closely among themselves and being obtained with less attention to minute details. Hence the cadmium chlorid is recommended.

A New Reaction of Formic Aldehyd and Its Detection in Food.

Within a couple of years formic aldehyd has begun to be somewhat extensively used as an antiseptic by preservers and dairy men and it has consequently fallen to the lot of the food analyst to ascertain means for its detection.

The scheme the writer offers for its detection is by means of the color it produces in milk when brought in contact with sulphuric acid. The substance under examination is rub-

bed up in the water, if necessary, and transferred to a flask adapted to a condenser. 20 cc. are distilled off into a test tube, to which 10 cc. of sweet milk is added. Hold the test tube in an inclined position and pour 5 cc. 1.84 gr. H_2So_4 slowly down the side without mixing. The acid sinks at once to the bottom forming 4 colored zones shading into each other but still quite clearly marked. Below is almost colorless acid shading above into light brown and then dark red brown. Above this dark ring a bright lemon yellow one of about $\frac{1}{8}$ inch depth, indicated formic aldehyd. In the absence of formic aldeyhd this zone is invariably a delicate rose, no suggestion of yellow being visible and vice versa, the yellow of the formic aldehyd completely removes the rose color from view. In case milk is to be examined distillation is of course omitted, the sample being simply diluted and treated as above.

The reaction is an exceedingly delicate one, 1-20 mgms. appearing as intensely yellow as 20 mgms. The formic aldehyd seems to decompose in a few weeks when added to preserved vegetables or fruits—at least it ceases to give this reaction. As, however, its antiseptic property also disappears at the same time, the test may be relied upon to detect its presence so long as it is accomplishing the purpose for which it is added.

The Volumetric Determination of Calcium.

The titration of calcium oxalate with potassium permanganate is an old process, but its application does not appear to be general. This is probably due to the inaccuracy introduced by hydrochloric acid as a solvent when used indiscriminately, and on the other hand to the unsatisfactory manipulation necessary to obtain a solution in sulphuric acid.

Experiment showed that phosphoric acid can be used, but for some reason the reduction of the permanganate proceeds very much slower than with the other, and the subsequent addition of sulphuric acid failed to remedy the fault. The titra-

tion can be carried out without error, but as each addition of the titrating solution turns the liquid pink, the color fading slowly, no guide is left as to the approach of the end.

The addition of manganous sulphate to the solution in hydrochloric acid was entirely void of good effect—if any was produced it was a bad one. It was found, however, that hydrochloric acid may be used safely if its amount be kept below a certain limit. This limit is 10 cc. of the 1.20 acid; an increase to 15 cc. already entirely confusing the end point. The conditions of the solution are:

Volume	200 cc.
Temperature	60° C.
Additions	10 cc. 1.20 HCl.
	10 cc. 1.84 H_2So_4.

Tenth normal solutions of oxalic acid in varying quantities were made up under these conditions and titrated with and without the addition of the hydrochloric. The results were perfect in all cases; that is, the solutions acidified with sulphuric acid alone gave identically the same reduction as with sulphuric and hydrochloric. The same applies to sulphuric and phosphoric acids.

As to the analytical value of the method, no special advantage is apparent in titrating over weighing when a pure precipitate is to be dealt with, especially where a mechanical blast is at hand for igniting to CaO, but often the precipitate is not pure, being contaminated with several weight-giving but not reducing substance; then the titration is of marked value. A case in point is the estimation of glycerol by conversion into oxalic acid, precipitating this as the calcium salt and titrating as above. Here we may have present calcium sulphate, and silicate. When desired to determine lime in this way a quantity equivalent to .1 gr. should be taken; the precipitate is then quite readily soluble in 10 cc. HCl. diluted and warmed.

While the method is not of extraordinary benefit in valuing a pure precipitate as against weighing, a rapid and fairly accurate analysis of limestone can be made by it as a basis. The principle involved is ascertaining the total alkalinity of the stone, then throwing down the lime with standard oxalic acid and titrating the excess with permanganate. The difference is the value of magnesia.

The details are as follows: One gram of limestone is weighed into a large platinum dish, covered with a foil and ignited intensely to the expulsion of Co_2. After cooling the mass is slaked with a little water and dissolved in 50 cc. $\frac{N}{2}$ hydrochloric acid. The action in the cold being slow is hastened by grinding the lumps with the flat end of a thick rod. When nothing but silica remains the contents of the dish is rinsed into a 250 cc. flask, a pinch of powdered phenolphthalein added and then back titrated with $\frac{N}{2}$ caustic alkali to the neutral point. The value thus obtained is the alkalinity due to lime and magnesia.

The red solution is decolorized by a cc. of strong hydrochloric acid and heated to boiling; 50 cc. $\frac{N}{2}$ oxalic acid added, then ammonia to alkaline reaction and boiled again. Allow to cool and settle, fill up to 1 cc. above the mark, filter and aliquot 50 cc. To this add 10 cc. strong sulphuric acid and warm to 60° C. for titration with $\frac{N}{10}$ permanganate. The total alkalinity minus the oxalic acid consumed by the lime is due to MgO, and is so calculated.

Several remarks on the foregoing are in order: The ignition serves the double purpose of expelling carbonic acid, (which permits the use of phenolphthalein as an indicator), and of converting insoluble silicates of lime and magnesia possibly present into basic soluble ones. The use of hydrochloric acid as a solvent being essential, carbonic acid can, of course, not

be boiled out after solution and the indicators not affected by carbonic acid are inapplicable; cochineal because of its decomposition by iron present and methyl orange because of its red color in acid solution (interfering with the final permanganate titration) and of its neutrality to the chloride of iron and aluminum, thus reckoning their neutralizing power as alkalinity. Phenolphthalein being without color in acid liquids and not turning red until all the iron and alumina are precipitated, is without objection.

This last must be borne in mind and no transitory pink tint taken as the end point but a full rich rose such as is produced in an equal bulk of a neutral liquid with the same indicator and a drop of half normal alkali. The flask is to be well shaken and the color must be permanent. It is also important that the relation between the acid and alkali be determined with phenolphthalein and not methyl orange for the same reason. Very few samples of caustic alkali are free from alumina and hence the titration by the two indicators will differ.

The usual alcoholic solution of the indicator cannot be substituted for the powder because of the consequent reduction of permanganate by the alcohol during the final titration. The oxalic acid had best be added to the acid solution, to prevent the precipitation of calcium carbonate by the carbonic acid in the ammonia.

It is recommended to standardize the permanganate solution directly on a calcium chloride solution of known value as determined by weighing as $CaSO_4$. The correction of 1 cc. for the volume occupied by the precipitate was determined by calculating from the shortage in a number of the titrations filling only to the mark.

A sample of limestone analyzed in this way and by the "alcohol method" gave:

	Gravimetric.	Volumetric.
Lime,	53.20	53.17
Magnesia,	0.41	0.55

The reading of the paper was followed by a discussion by Mr. J. M. Camp, Mr. A. G. McKenna, Dr. F. C. Phillips and the author of the paper, after which Dr. Phillips read an interesting paper on the preparation of Methyl Orange.

ON THE PREPARATION OF METHYL ORANGE.

BY FRANCIS C. PHILLIPS.

The sharpness of the color changes which characterize methyl orange when its aqueous solution is acidulated, the intensity of its color, its ready solubility in water, together with its insensitiveness toward the weaker acids, have served to render this substance of much value as an indicator.

It is a matter of common experience, however, that commercial samples of this dye are occasionally found which, although apparently pure, prove to be totally unsuited for chemical use.

Some of the commercial methyl orange contains soluble brownish black impurities which tend to mask the normal color changes peculiar to the pure dye.

These may be of the nature of by-products formed in the process of manufacture.

In other cases the difficulty seems to arise from another cause. The needs of the dyer and the analytical chemist, as regards organic coloring substances, are often diametrically opposite. The chemist requires colors which undergo the greatest possible alteration in shade when the reaction of their solution is changed, such being the essential quality of an indicator.

On the other hand the dyer calls for colors which, on silk or wool or vegetable fibre, are permanent, and either not affected, or only to a trifling extent, by acids or alkalies. While methyl orange finds uses as a dye its change from yellow to red constitutes a disadvantage from the dyer's standpoint. Other orange colored dyes are manufactured which closely resemble

methyl orange, but which are far less subject to change of shade. These are largely used by dyers and it seems that some one of these colors is occasionally sold to a chemist in place of methyl orange. It is hardly necessary to say that such colors, although applicable to textile fabrics, are unsuited to the purposes for which indicators are ordinarily used. The more permanent orange colors are often scarcely distinguishable from methyl orange when their dilute solutions are compared.

The commercial color may be tested or, if necessary, purified, but methyl orange is so easily manufactured on a small scale, and in a very pure state, that there seems to be no reason why it should not be made in the laboratory for use as it is needed.

Thinking it might be of interest to some of the members of the Section to prepare the color, I submit the following details of a method which has been found to give very satisfactory results as regards both quantity and quality of product:

Ten grams of sulphanilic acid, pulverized and dried on the water bath before weighing, are dissolved in a solution of 3.5 grams anhydrous sodium carbonate in 150 cc. of distilled water. To this solution add 4.2 grams of sodium nitrite dissolved in 20 cc. of water. Cool the mixture by dropping in about 50 grams of broken ice and add slowly 15 cc. of hydrochloric acid of 1.08 sp. gr. Should the ice melt more must be added, as it is indispensable that the temperature should not rise much above freezing point. Call this solution No. 1.

Prepare a second solution by placing 7 grams of dimethyl aniline in a small beaker, adding 25 cc. water and concentrated hydrochloric acid until a drop taken out on a glass rod and allowed to fall upon a strip of fuchsin test paper just suffices to cause the fuchsin color to be bleached. (Litmus and other common indicators cannot be used here, as they fail to show the end point. Fuchsin is instantly bleached by a trace of strong acid, and in the present case serves to show at once

when the above-named base, dimethyl aniline, has been fully neutralized by the hydrochloric acid.) Call this solution No. 2.

After solution No. 1 has remained standing for about ten minutes, and the ice has nearly or quite all melted, solution No. 2 is to be slowly added. The mixture is well stirred and left at rest for ten minutes. After the solutions are mixed it is no longer necessary to cool. A deep red precipitate forms and increases in quantity, rendering the fluid thick. 30 cc. of 10 per cent. sodium hydrate solution are now added and 50 grams of powdered pure salt, and the mass, which becomes now more and more viscid, is well stirred. After standing for a few hours the contents of the vessel become almost solid from separation of the color. Filter, using suction, and wash on the filter with very little water. The precipitate on the filter consists of methyl orange in a nearly pure state. Its color appears as a reddish brown. The filtrate contains some methyl orange, but in addition to this impurities of a dark brown color and should be discarded.

Dissolve the precipitate on the filter in about 200 cc. of boiling water and add 50 grams. of finely powdered pure salt. (In strong brine the color is nearly insoluble and by the use of salt the yield is increased.) The methyl orange separates in minute crystalline scales. For the sake of greater purity the crystals may be redissolved and reprecipitated by salt. It is best to dry by pressing in filter paper without heating.

Thus obtained methyl orange appears as an amorphous powder, varying in color from brown yellow to deep brown, the color depending upon the fineness of the powder. The highly lustrous scales which are seen during its separation from solution lose their brilliancy during filtering and drying. The dilute solution of methyl orange possesses an orange yellow color which changes to a beautiful scarlet red on addition of a strong acid.

The reactions involved in the above process are as follows: Aniline hydrochloride in presence of the nitrous acid of the sodium nitrite yields the following change:

$$C_6H_5NH_2HCl + HNO_2 = C_6H_5N = NCl + 2H_2O$$

Aniline hydrochloride. Diazo-benzene chloride.

The diazo-benzene chloride belongs to a class of compounds which are very unstable and noted for their tendency to decompose explosively when dry. Its solution can only be kept from decomposition by maintaining a very low temperature and hence the use of ice. It can be used without danger or inconvenience so long as it is not permitted to crystallize out from the solution nor to become heated. The degree of dilution above indicated prevents it from crystallizing out. If its solution is warmed it is at once slowly decomposed and the yield of methyl orange will be lessened. The diazo compound forms but a transitory stage in the process for on adding to it the solution of dimethyl aniline hydrochloride (solution No. 2) the following change occurs:

$$C_6H_5N = NCl + C_6H_5N(CH_3)_2 = HCl +$$

Diazo-benzene chloride. Dimethyl aniline.

$$C_6H_5N = NC_6H_4N(CH_3)_2$$

Methyl orange.

An atom of chlorine of the former compound unites with a hydrogen atom of the dimethyl aniline, forming hydrochloric acid and methyl orange, or, to give it its chemical name, dimethyl-amido-azo-benzene is precipitated.

For the sake of simplicity in the above formulas it has been assumed that aniline hydrochloride was used. In practice sulphanilic acid, a substance formed by the action of concentrated sulphuric acid upon aniline, is commonly used. This leads to a product which differs from the methyl orange above mentioned in containing an HSO_3 group, and which is known as a sulphonic acid.

Ordinary commercial methyl orange, which is also known as Poirrier's orange, Orange III, or Helianthin, is a sodium salt having the formula

$$C_6H_4 < \begin{matrix} NNC_6H_4N(CH_3)_2 \\ SO_3Na. \end{matrix}$$

Used in the form of a sulphonic acid it possesses the great advantage that it is readily soluble in water, while the original color is nearly insoluble.

The method of preparation I have detailed is that given by Gattermann, "Die Praxis des Organischen Chemikers," slightly modified. See also for a very excellent method of preparation Möhlau, Berichte der deutschen Chem. Gesell, vol. 17, p. 1490.

A. G. McKenna,
Secretary C. S.

Engineers' Society of Western Pennsylvania.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

June 16th, 1896.

The regular monthly meeting of the Engineers Society of Western Pennsylvania was held in the lecture room of the Society, 410 Penn Avenue, Pittsburg, Tuesday evening, June 16, 1896, President W. G. Wilkins in the chair.

The meeting was called to order at 8:35. There were 35 members and visitors present.

The minutes of the last meeting were read and approved.

Reporting for the Board of Direction, the Secretary read the names of two applicants for membership, approved by the Board, and recommended for election.

The following named applicants were elected to membership: William A. Wilson, Civil and Mining Engineer, and Arthur W. Sewall, Manufacturer.

Mr. Emil Swensson as a member of the House Committee reported that they had received $1050, but that he feared, when all the bills were paid, they would find the funds running a little short.

Mr. Arthur Kirk presented some additional remarks on the subject of Good Roads, the title of his paper read at the May meeting.

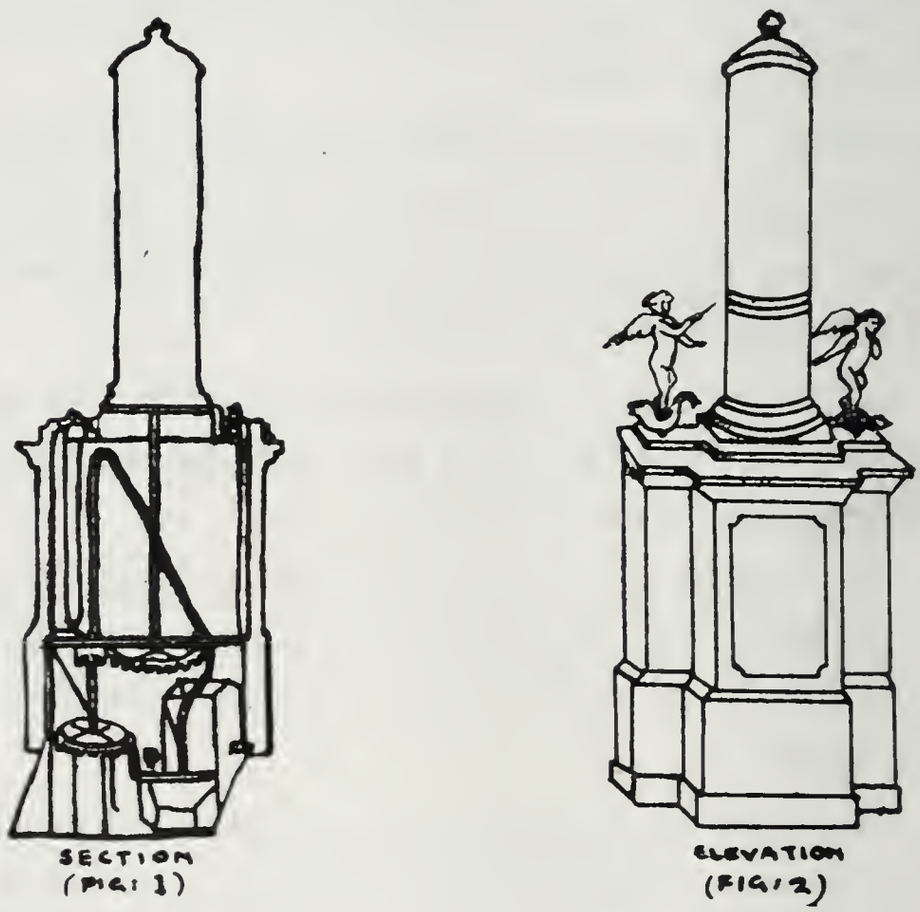
Following Mr. Kirk's remarks came the reading of a paper entitled "Notes on the Designing and Manufacture of Gears" by Mr. Samuel Groves.

"NOTES ON THE DESIGNING AND MANUFACTURE OF GEARS.

BY S. GROVES, M. E., OF TAYLOR, WILSON & CO., LTD., ALLEGHENY, PA.

I

In the domain of applied mechanics, the toothed wheel—or third mechanical power as it is called—has played an important part. The delicate wheels in the mechanism of a lady's watch on the one hand, and the colossal gear of the Ferris wheel on the other, may be cited as extreme examples of its application. Every mine, factory and mill in the world, bears witness to its universal utility. This unique device for the transmission of power, was invented by an Egyptian named Ctesibius, a member of the famous school of Alexandria—who flourished



First Application of Toothed Wheels, 120 B. C.

about 120 years B. C. It was first applied to operate a Clepsyora or "water dial" (Figs. 1 and 2), which consisted of a cylinder resting on a pedestal; two figures were placed on the latter, one of which dropped water from its eyes, whilst the

other pointed with a wand to the hour marked upon a vertical line drawn upon the cylinder. This cylinder turned on its axis once a year, and its rotation was imparted by means of two pinions—each with 10 teeth, and two gears with 60 and 61 teeth respectively, receiving their primary impulse from a revolving bucket wheel. Many ingenious contrivances have been operated by gears since the days when Egypt was in her glory; but few have excelled in interest the appliance which first called forth the inventive genius of Ctesibius, the renowned schoolman of Alexandria. It is probable that these primitive toothed wheels were cast in bronze, for the founding of metals, especially brass, was a well-known art in those days on the banks of the Nile. As far as one can gather, the teeth of these ancient toothed wheels, consisted simply of square cogs on the face of circular discs; having no regard to ease of movement, lessening of friction, or saving of propelling power. It was not until nearly 1800 years latter, that any marked advance in this direction was made. In the year 1674, however, a Danish mathematician named Roemer, conceived the idea of forming the contour of the teeth on the lines of epicycloidal curves developed by means of generating circles. And about the same time, De Laihre, published a treatise in which he demonstrated that "*if the tooth of either a wheel or pinion be formed by a portion of an exterior epicycloid described by a generating circle, of any dimension whatsoever, the tooth of its follower will be properly formed by a portion of an interior epicycloid described by the same generating circle. The object being, to obtain a uniform pressure and velocity throughout the machine, so that the wheels, whatever might be their position, would act uniformly and equally, and that the surfaces of the teeth touching at a point, should roll over each other and avoid all friction.*"

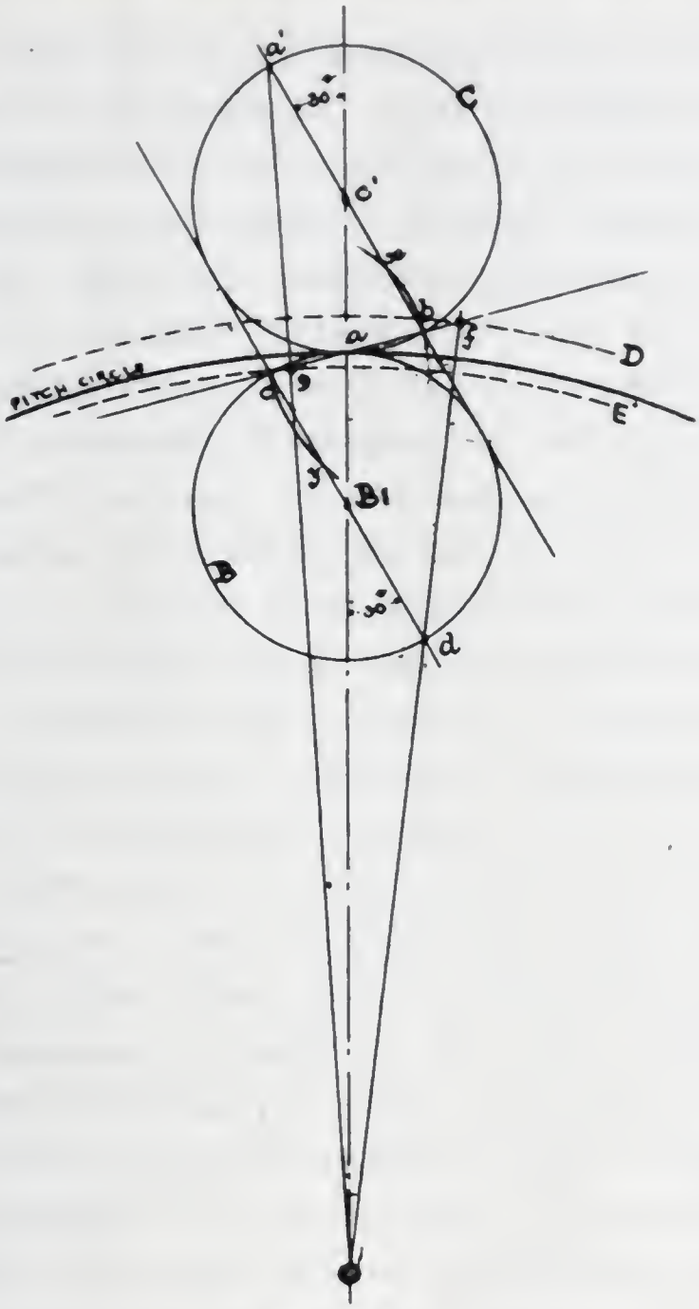
From that time until now, the epicycloidal form of tooth for spur wheels, has been adopted as the almost universal system.

I have not deemed it necessary to describe graphically the

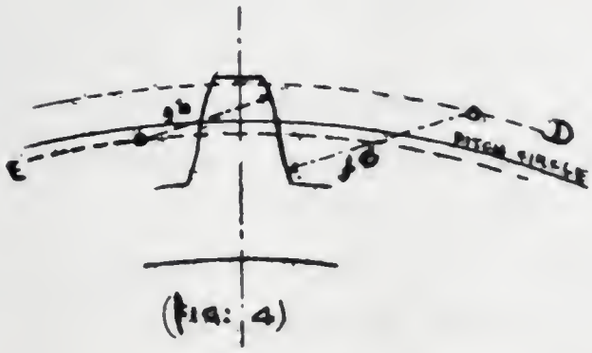
epicycloid and involute, assuming that all are familiar with these geometrical forms; whilst, however, this may be true, it yet remains a fact, that very few in either the average draughting room, or pattern shop can develop quickly, by means of generating circles, the epicycloidal teeth of any given wheel and pinion. Most rely upon odontographs like those of Willis, Robinson and Grant; or, Charts like those of Walker. Consequently, if these "short cuts" are not to hand, the proportioning and contouring of the teeth is a very laborious and uncertain procedure; all because the method of development is not an intellectual possession applicable in all cases. But is there a simple, reliable, universal system of developing the epicycloidal teeth of gears? I verily believe that we have such a method in the geometrical formula of Reuleaux, which I have proved by extensive experience to give excellent results, as regards depth of contact and harmonious working.

The *modus operandi* is as follows: Assuming the total depth of tooth to be .7 of the pitch, then the formula for determining the diameter of the generating circles = pitch × 2, or, 1 inch diameter for teeth $\frac{1}{2}$ inch pitch. This rule holds good, no matter what may be the diameter of the wheel.

Method. (Fig. 3) assuming pitch diameter = 8 inches, and pitch of teeth, $\frac{1}{2}$ inch, then pitch circle = 4-inch radius, and rolling circles C and B=1 inch diameter. Draw two parallel lines a c b and c b d through the respective centers of the rolling circles, each making angles of 30 degrees with the vertical center line. Draw line c a b f through points where c b intersect the generating circles. Connect a and d with o, and the points where these two lines intersect line a c b f at g and f respectively, will determine the radial lines D. E. from which the radii of the upper and lower flanks f c and g b are struck.



(FIG: 3)

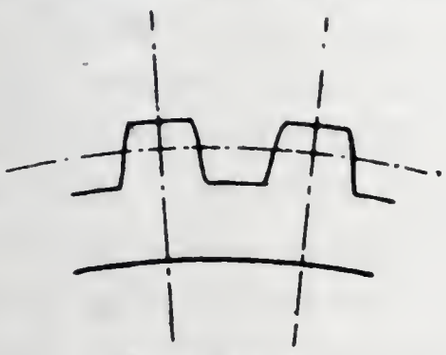


(FIG: 4)

With this demonstration of Reuleaux's simple and practically accurate geometrical method for "laying off" the epicycloidal teeth of gears, we proceed to say a word or two about involute teeth.

It cannot be denied that there is considerable difference of opinion among engineers as to the comparative mechanical advantages of the *involute* and *epicycloid* for contouring the teeth of gears. Because Brown & Sharpe have adopted the involute for their standard gear cutters—since this shape is easier to make and less costly to produce than the dual profiles of epicycloidal teeth—many have unreasonably jumped to the conclusion that the *involute* is necessarily the better form of tooth. The exact experiments, however, of Hawkins, Reuleaux, Cromwell and others, have demonstrated the very contrary, and have credited the epicycloidal tooth with the following advantages: (1) That the minimum number of cycloidal teeth which may be geared satisfactorily in a pair of like diameter, is 7, whilst the smallest number of workable *involute* teeth under similar conditions is 11. (2) That in cycloidal teeth less power is lost in overcoming friction than in involute teeth. (3) That cyloidal teeth, when considerably worn, retain their original shape much better than involute teeth under similar conditions. Indeed, the only advantage possessed by involute toothed gears is, that the shafts upon which they are hung, may be slightly varied without disturbing their harmonious working, whereas, any alteration in the centers of cycloidal toothed gears is detrimental to their accurate rotation and full efficiency. It is probably this latter fact, which has induced many an Engineer in charge of rolling mills, to look with favor upon the involute form of tooth; for the operating mechanism of a train of rolls, or, a bloom shear, is constantly subjected to such terrific shocks and abnormal strains that it is next to impossible to keep the journals free from excessive wear, and the shafts from getting out of line. Had not steel gears come upon the scene, we should doubtless have heard more about the relative merits of the involute and the cycloid. The discussion was silenced by the advent of costly steel castings, excessively proportioned. Keen competition, however, and enforced economy, is opening out the question again. But the tendency

of late has not been to take up the question of tooth curvature; but to entertain an altogether heterodox idea, involving not only a new departuure, but a radical change in our conception of the conventional mechanics of gearing. Until very recently, the aim of every designer of toothed wheels was to get two or more teeth in gear at a time. To accomplish this, it was necessary that the teeth should be long and seven-tenths of the pitch became the standard length. In calculating the horse-power of a gear, the tooth was always recognized as a cantilever, liable to be broken off at its root by a lever strain. The new departure consisted, in so proportioning the tooth, that the old lever strain was transformed into a shear strain; instead of *breaking* off, it had to be *pushed* off. This desired economy was attained by reducing the length of the standard tooth from .7 to say .5 of the pitch, and shaping the flanks in such a manner that although there was only one tooth in gear at a time, yet wherever gears with this short tooth were practically applied, they rolled so noiselessly and with such manifest power of resistance, that the spectator could only stand and wonder why long teeth should ever be used for the transmission of high powers. It was my good fortune to be the first person in this country to publicly advocate the adoption of the "one tooth in gear system" for high powers; in articles which appeared under my signature in the *American Manufacturer* and *Iron Age* of October 18th, 1894, also *The Pattern Maker's Journal* and *The Foundry* for November of the same year; all setting forth the general advantages of the system, and detailing in-



SHORT TOOTH.
FIG. 5.

LONG TOOTH
FIG. 6

stances of its practical application. Fig. 5 represents a reduced outline of short teeth 6-inch pitch, as cast on two gears 8 inches—2 inches diameter x 18 inches face, each weighing $9\frac{1}{4}$ tons each—made for the new tin plate Rolling Mills at the La Belle Iron Works, Wheeling, W. Va., for which Mr. Charles Hyde, of Pittsburg, was Engineer. Fig. 6 shows standard epicycloidal teeth of like pitch, for the purpose of comparison. In the Spring of 1895, the 13-inch "Belgium" mill of the National Rolling Mills, McKeesport, Pa., was disabled owing to the breaking of a large steel gear 8 feet 4 inches diameter—with its complementary pinion having triple staggered teeth. As many as six teeth in a row were torn out at the roots. Gears with Double Helical teeth had failed previously. I was requested by the Engineer to investigate the case, and without hesitation, undertook to design a cast-iron gear and a pinion with straight, spur teeth, *having only one tooth in gear at a time.* The offer was accepted. The gear was 8 feet 4 inches diameter, 7-inch pitch, 22-inch face, weighing $12\frac{1}{2}$ tons, and the pinion $4\frac{1}{4}$ tons. This pair have been running uninterruptedly for over a year, demonstrating that with properly designed short teeth, instead of long teeth, gears made of cast iron may succeed, where steel proved a miserable failure.

Indeed, one could occupy the whole of the time at our disposal in the citation of trustworthy facts showing the unwisdom of using teeth .7 of the pitch on large spur driving wheels and pinions, transmitting great powers and running at high velocities: for the evidence is overwhelming as to their unfitness to resist wear and tear. On the other hand, one could advance case upon case, instance upon instance, proving the remarkable adaptability of short teeth .5 of the pitch—or less, working under like conditions—to successfully resist the wear and tear of actual work. My object, however, is not to do a piece of special pleading in defense of a "fad," but to still further popularize an idea, the practical adoption of which I believe would be on the lines of

progress and economy, and I may be permitted to remark in concluding this part of the discussion that when the one-tooth-in-gear system comes into general use for high powers—as it assuredly will—then high-priced, irregular gears of the Double Helical and Staggered tooth type—which are almost impossible to mould with the necessary degree of accuracy; which are exceedingly difficult to set on their shafts; and which are after all, of questionable advantage—will be relegated to the limbo of curiosities; for spur wheels with short teeth embody all the advantages claimed for these irregular gears as regards strength, and at the same time are manifestly superior as regards mechanical adaptability and practical application.

Having dealt with the question of teeth, we now pass on to the allied subject of the spokes, or arms. The most artistic form of arm is undoubtedly the oval, but its use is limited to comparatively narrow faced gears, for its minor axis is parallel to the face of the teeth, thus leaving a portion of the run on either side of the arm unsupported, consequently, it is usual to introduce |—| sectioned arms into gears with wide faces, since, by this form, the entire face is supported without excess of metal, whilst the strain upon the teeth is equally distributed throughout the entire plane of the gear.

ARMS.

In the general designing of a gear wheel there is a factor of supreme importance, which one has ever to keep in mind, and that is, the necessity of attaining uniformity of section, with a view of realizing uniformity of *shrinkage*. I well remember—among other instances of the deplorable consequences of neglecting this law of uniform sectioning—one remarkable case. A gear wheel had been cast one evening, and the next morning was brought out of the Foundry to the cleaning ground. About noon, a noise was heard like the report of a cannon. Upon examining the wheel, it was discovered, that one of the slender cross arms had separated from the rim, and there was a space of nearly $\frac{3}{8}$ inch; indicating that the rim had been

in terrific tension. The cause of the bursting was this: the gear—for which this was a substitue—had been broken through the rim, owing to some severe shock or blow; consequently, it was ordered to make the rim about three times the thickness of the tooth on pitch line. This was done, and it made the sectional area of the rim about three times that of the arm where it connects to the rim; hence, when the gear was cast, the metal in the arm cooled much quicker than that in the rim, so that finally, the comparatively delicate section of the arm could not resist the enormous shrinking pull of the hub and root of the arm on the one hand, and the heavy mass in the rim on the other, and consequently, burst asunder. True, the fatal effects of this inequality of sectioning and shrinkage might have been obviated by removing the sand from the hub and rim of the newly poured casting, thus accelerating the cooling of these massive parts, and balancing the cooling rate of the lesser arm sections. But there is no need for resorting to these tricks of the Foundry, if the law of equal sectioning is observed. In subsequent practice, the object lesson cited, was a constant reminder of the necessity of making the arms and rim of a gear as nearly of equal sectional area as the circumstances of the case would permit. It is a sound practical rule in gear design, to make the thickness of the rim equal to the thickness of the teeth on the pitch line —for gears without shrouds.

HUB.

Again, Some Engineers have strange notions about keys and keyseating. A small shaft may occasionally be seen with an abnormally large key, hence the metal between the outside of the gear hub, and the corner of the keyseat in same is very meagre. Many a gear wheel has been torn from its shaft, the tear having been caused by an oblique rent starting at the corner of the keyseat, in accordance with the law that the strongest part is its weakest point. (Fig. 7.) It is an excellent device, to re-inforce all hubs over their keyways,

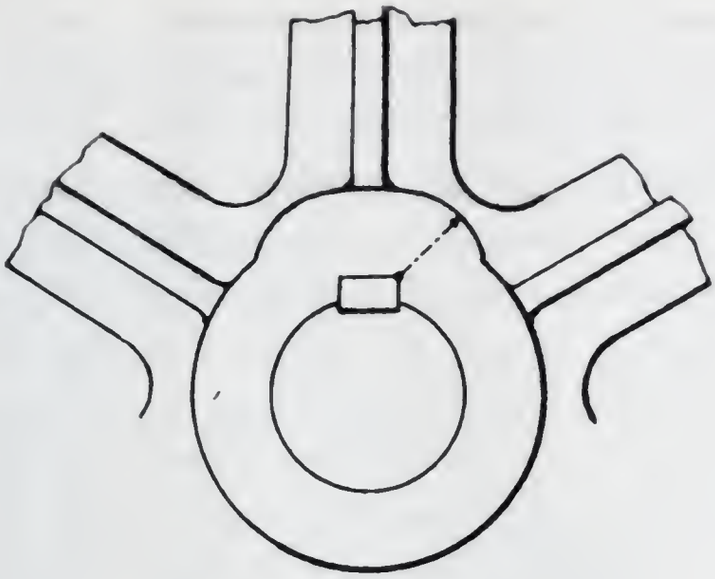


FIG. 7

(Fig. 7.) by taking the corner as a centre, and striking a radius equal to thickness of hub, $+\frac{1}{8}$ inch for small and thickness $+\frac{1}{4}$ inch for large bores. By so doing, the thickness of metal in the hub may be reduced to a minimum, thus still further contributing to an equalization of section, and consequently a sounder and stronger casting.

II.

MANUFACTURE.

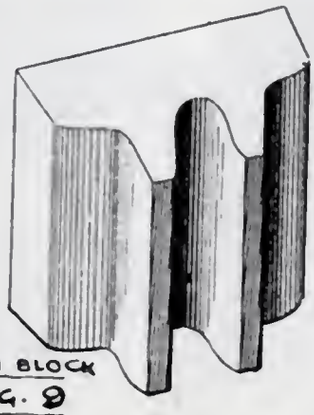
We now leave the debatable ground of opinion in the designing of the teeth, arms and hubs of gears, for the practical domain of manufacture.

The first cast iron gear wheel was made about 1782, at the Coalbrooke Dale Ironworks, Staffordshire, England. Until about 25 years ago, the common practice in the foundry world was, to make the castings from full patterns, or in some instances, by means of a section of the rim, while in others the teeth were formed in cores. About the year 1870, however, Jackson, of Manchester, England, began to make gears by machinery, doing away with full patterns altogether. From that time until now, the machine moulded gear has been gradually superseding the old-fashioned hand moulded gear, made from full patterns.

"That machine moulding is superior to hand moulding in the manufacture of gear wheels, needs in these days of enlightenment, no elaborate proof. Pattern moulded gears are necessarily defective, for the diameter at the opposite ends of the teeth must be unequal owing to the draft given to the pattern, while the rapping needed to draw the pattern oftimes causes the wheel to be out of round. Besides, whoever saw a full pattern drawn without patching? It is claimed that the defect due to draft is practically overcome by carefully meshing the gears with "cope" and "drag" together. A manifest fallacy, for if the teeth are tapered, their driving contact can only be at the extreme ends, and not across the entire flanks, which accounts for the common experience of the breaking of gear teeth at the corners. But even where the first castings from complete wooden patterns are fairly accurate, the rapping and soaking with water, essential to the withdrawal of the pattern from the sand causes it to warp, so that when the pattern is taken out of the store for subsequent castings, it is found to be so radically out of shape that another expensive pattern has to be made. Then again, look at the area needed to store these complete patterns, especially the larger sizes! Further, Take the matter of pattern expense. A full pattern, say 40 inches diameter, 84 teeth, 1½ pitch, 4½ face, properly and strongly made, would take an expert pattern maker at least five days, and cost from $20 to $25. If, however, it was proposed to make a gear of the same, dimensions on a machine like the one illustrated (Fig. 8),

Fig. 8.—The Groves Patent Moulding Machine.

the only pattern needed would be, a block having the form of a single tooth space for making the teeth moulds (Fig. 9),



TOOTH BLOCK
FIG. 9

a sweep for forming the tooth backing; a box for mak-

ing the green sand arm cores, and another plain box for making the dry sand centre core. These preparations would be made in about two days, at less than one-half the cost of the complete pattern, and the work would be in the Foundry, the gear cast, cleaned, and in the machine shop before the complete pattern was even into the Foundry. Besides, with ordinary care, 100 castings could be made off these preparations without any appreciable diminution in the matter of accuracy and finish. I have here a photographic print of a pair of large

Fig. 10.

gears (Fig. 10) 74-inch .50 pitch diameter, 78 teeth, 3-inch pitch, 8-inch face, double shrouded, weighing about 1¼ tons each—made upon one of our machines within the last few weeks. The feature about these wheels is, that neither hammer nor chisel was used in the cleaning of the teeth, for upon hoisting the castings from the sand the burnt facings simply peeled out of the tooth spaces, leaving a bright smooth skin, having the appearance of cut gears; indeed, gears made with this degree of perfection are immeasurably superior even to cut gears, since, although the latter give smooth running, they do so at the expense of the life of the wheels, by the cutting away of the hard skin of rich combined carbon from the flanks of the teeth; leaving the opener grained graphite for a wearing surface. In fact, so superlative are the advantages of moulding toothed wheels by machinery—namely, in the

absence of costly patterns,
abandonment of draft, and in the
greater accuracy of pitch—

that the passing of the antiquated hand moulded pattern gear, is only a matter of time, for increased economy and mechanical efficiency are factors which the progressive Engineer can not afford to disregard.

DISCUSSION.

THE PRESIDENT.—You have listened to Mr. Groves' excellent paper, and no doubt he is willing to answer any questions which the members may see fit to ask.

G. E. FLANAGAN.—Mr. President, I would like to ask Mr. Groves a question in reference to that short tooth gear there; what would be the proper length of a tooth in relation to the pitch for a short tooth?

MR. GROVES.—Some makers have adopted a 5-10 pitch as the proper length and have found it to give good results.

MR. FLANAGAN.—What draft should be allowed in a tooth of a full pattern to enable a moulder to draw it from the sand properly? We must allow some little draft in making a tooth

thicker at one end than at the other; what is the smallest draft that a moulder should be allowed on a pattern gear?

Mr. Groves.—Well, here is one more advantage of the machine moulded gear; it does not require draft at all, the teeth being perfectly straight. I do not know that there is any standard by which you can tell the amount of draft to be allowed in a pattern moulded gear. It would depend somewhat on the moulder. My experience has not been large in pattern moulded gears, but for a full pattern, I think the draft should not be less than 1-16 of an inch, but in machine moulding, no draft is allowed as none is required.

Mr. Flanagan.—I would like to ask the gentleman's opinion in regard to placing the keyseat; in case a wheel is cast with six arms and no reinforcement has been allowed, would you approve of placing the keyseat directly opposite one of the arms, or centrally between them?

Mr. Groves.—If the hub of a gear is built without reinforcement over the proposed keyseat, then the keyseat should be between the arms, since the rending of the hub would take place obliquely from the corner, and if the hub be reinforced in accordance with the plan outlined in my paper, (illustrates on the board) then the keyseat should be placed in line with one of the arms.

Some discussion here took place with regard to the proper method of curving the teeth on a short tooth gear. Mr. Diescher arguing that if we take a standard tooth gear and turn off a portion from the point downward it would work equally as well as the standard tooth, but Mr. McGary said that his practice in the shops was just the opposite to this, since he found that gears which were too long to mesh properly, when turned down at the points worked very unsatisfactorily, with which Mr. Groves coincided exactly.

Another member here asked which Mr. Groves considered the proper method of spacing the teeth on the pitch surface, the chordal or circumferential pitch, to which Mr. Groves replied that in his opinion the most approved method would be the circumferential pitch, but the chordal pitch, which is easier to manufacture, was approximately near enough for every day practice.

The meeting adjourned at 10.30 P. M.

Daniel Carhart,
Secretary.

CHEMICAL SECTION.

The Chemical Section of the Engineers Society of Western Pennsylvania met at the Society's rooms, 410 Penn ave., Pittsburg, June 18th. J. M. Camp in the chair. The meeting was called to order at 8.30 P. M. Seven members were present. The minutes of the last meeting were read and approved. Papers on the "Determination of Chromium," by Mr. A. G. McKenna, and notes on the "Analysis of Mill Cinder," by Jos. M. Wilson, were read and discussed informally by the members present.

THE DETERMINATION OF CHROMIUM.

BY A. G. M'KENNA.

The following method for the determination of chromium in steel will be found more accurate and rapid than any of the published methods known to the writer. By its use he has made several thousand chromium determinations with uniformly satisfactory results.

The process is based upon the well known fact that chromic salts can be oxidized completely to chromic acid by the addition of potassium chlorate to a concentrated nitric acid solution, and the fact, not so well known, that the presence of nitric acid does not interfere with the titration of chromic acid in a cold solution, by means of ferrous sulphate and permanganate.

In case the steel contains manganese and a determination of the same is wanted in addition to the determination of chromium, the method is as follows: Weigh 3 grams of steel into a 400 cc. flask, add 35 cc. of strong hydrochloric acid and boil for five or ten minutes, which will be found sufficient to dissolve completely, even the highest chrome steels. When most of the hydrochloric acid is boiled off, add 150 cc. of strong nitric acid, and continue the boiling until no more brown fumes are seen at the mouth of the flask, showing that the hydrochloric acid has all been driven off. Remove the

flask from the flame or hot plate, allow to cool for two or three minutes, and then add 10 grams of potassium chlorate in crystals. It is best to allow the solution to cool slightly before adding the chlorate in order to diminish the violence of the effervescence due to the action of the chlorate on the chromic salts. Replace on the hot plate and boil down to about 40 c.c. in order to decompose completely the potassium chlorate. It is necessary to decompose the chlorate completely or results will be from .1 to .2 per cent. high, but the amount of nitric acid left in the solution is non-essential. At this stage, the chromium will all be in the solution in the form of chromic acid. The manganese will be precipitated as $Mn\ O_2$ and generally some crystals of potassium nitrate arising from the decomposition of the chlorate will have separated out. Filter off the $Mn\ O_2$ on an asbestos plug, washing the precipitate three times with cold water. Transfer the asbestos and the $Mn\ O_2$ to the flask, in which the original precipitation was made, titrate with ferrous sulphate and permanganate, according to Williams' well known modification of Ford's method.

Make the filtrate from the $Mn\ O_2$ which contains all the chromic acid in a nitric acid solution up to about 500 cc. with cold water, and add standardized ferrous sulphate solution in slight excess indicated by the disappearance of the yellow color of the chromic acid and the appearance of the clear green color of chromic nitrate; then add standardized permanganate to oxidize the excess of ferrous sulphate used; the end point being the well known faint pink color.

The standard ferrous sulphate is made by dissolving iron wire of known purity in an excess of dilute sulphuric acid, diluting with water until 1 cc. contains .003223 grams of iron in the ferrous condition.

The permanganate solution is made by dissolving 1.818 grams of pure $K\ Mn\ O_4$ to the liter of water; 1 cc. of the permanganate solution will then oxidize exactly 1 cc. of the fer-

rous sulphate solution, and the number of cubic centimeters of ferrous sulphate used to reduce the chromic acid minus the cubic centimeters of permanganate necessary to oxidize the excess of ferrous sulphate will give the amount of chromium present in milligrams.

For example, to 3 grams of steel treated as above, 35 cc. of the ferrous sulphate are added to reduce the chromic acid and then 5 cc. of permanganate solution is found necessary to produce a permanent pink; hence 3 grams of this steel contains .03 grams of chromium or one per cent. If these same solutions are used for the titration of the $Mn\ O_2$ by the Williams method each cubic centimeter of ferrous sulphate used in excess of the cubic centimeters of permanganate used in the back titration equals .001418 grams Mn.

In case the determination of manganese is not required and it is desired to avoid the filtration from the $Mn\ O_2$ the method may be modified by diluting the solution after it has been boiled down to 40 cc. by the addition of 100 cc. of water and a few drops of hydrochloric acid, which will at once dissolve the $Mn\ O_2$ without action on the chromic acid. The solution then must be boiled for a few minutes to remove the chlorine set free by the reduction of the $Mn\ O_2$ after which it may be cooled and titrated as above.

In very many chrome steels the amount of manganese is so inappreciable in comparison with the chromium that for practical results it is not necessary to remove the $Mn\ O_2$ either by filtration or solution in hydrochloric but the solution may be diluted after the evaporation to 40 cc. and titrated at once. Of course, in high chrome steels it is not necessary to take more than a gram for the analysis.

For the determination of chromium in ores, slags and ferro chromes, beyond a doubt the best method of decomposition is by fusion with sodium peroxide in a nickel crucible, which brings about complete decomposition in two or three minutes, if the sample is at all finely ground.

Duplicate determinations on ores, slags and ferro chromes made by the solution of the sodium peroxide fusions in nitric acid and oxidation by potassium chlorate gave on titration equivalent results to those obtained by the usual method of acidifying with sulphuric acid after decomposing the excess of per oxide by boiling in a water solution. Consequently there would be no advantage in the chlorate method for these over the usual method, except that by obtaining a clear solution of fusion in the nitric acid preliminary to oxidation with chlorate all danger from incomplete decomposition leading to the presence of particles of metal, which might reduce some chromic acid on the addition of sulphuric acid is avoided.

However, in the writer's experience, the decomposition has always been complete.

NOTES ON THE ANALYSIS OF MILL AND PUDDLE CINDERS.

JOS. M. WILSON.

Mill cinder is used in our furnace as part of the burden and is almost wholly brought in car load lots, as the railroad people are constantly pushing us for prompt unloading, methods for rapid determination of the constituent elements of these cinders are important. Formerly we were required to return the Iron and Insoluble quickly and later the Silica. At present Iron and Phosphorus, with occasionally Manganese. Our methods are as follows :

Iron.—Weigh out .25 and .5 grams into lipless beakers, moisten with 10-15 cc. water, making certain that the mass is well broken up, add quickly 20 cc. HCl conc., cover, boil gently 20 minutes (or let digest upon steam table one hour, then bring to a good boil), add $Sn\ Cl_2$ solution, from a pipette, till the liquid is colorless, boil two minutes, remove to steam table and allow to settle, the supernatant liquid must be colorless ; the residue will vary from light gray to black according to the amount of powdered coke present.

Wash into a No. 5 or 6 beaker, rinse small beaker thoroughly with cold water, taking care to remove *all* the insoluble matter. Make the volume 300 cc., stir well, add 30-40 cc. $HgCl_2$, solution, *all at once*, stir, run in $K_2Cr_2O_7$ until four drops give no blue coloration with a drop of Ferricyanide indicator in one-half minute.

Solutions used: *Bichromate*, 4.9 grms. $K_2Cr_2O_7$: 1,000 cc. H_2O. 1 cc = .005 grams Iron. *Stannous Chloride*: 100 grms. in 1,000 cc. HCl (1-1). *Mercuric Chloride*: 50 grms. in 1,000 cc. H_2O. *Ferricyanide Indicator*: 5 cc. of a 5% solution in 40 cc. H_2O.

Insoluble and Silica.—Weigh 1 gram into a 5-in. Royal Meissen dish, stir up with 20 cc. H_2O, add 20 cc. HNO_3 conc., stir well, cover, boil dry, ignite till all acid smell is gone, cool, add 10 cc. HCl, conc., boil dry, ignite, cool, add 25 cc. HCl, boil down to 10 cc., add 30 cc. H_2O, boil up, filter through 9 cm. filter, wash hot HCl 1-1 and cold H_2O twice, and twice with cold H_2O, ignite, cool, and weigh *insoluble*. Fuse "insoluble" with 6-8 times its weight Na_2CO_3, dissolve the melt in H_2O, acidify HCl, evaporate dry, ignite, cool, pour on 10 cc. HCl conc., dry and ignite to render SiO_2 entirely insoluble and granular, cool, add 25 cc. HCl, boil down one-half, add 30-40 cc. H_2O, boil up, filter on 9 cm. filter, wash twice with hot H_2O—filling filter each time to remove salts—then with hot HCl 1-1, and cold H_2O twice, then four to six times with hot H_2O, ignite, cool and weigh; or moisten insoluble with H_2O, add HF till a clear solution is obtained, then 5 or 6 drops H_2SO_4 1-3, evaporate, dry, ignite on hot plate till no more SO_3 fumes come off, then heat to redness, cool and weigh, loss = SiO_2.

Manganese is determined by precipitation with $KClO_3$, purification of the MnO_2 precipitate and final weighing as $Mn_2P_2O_7$, by the acetate method or by color.

Phosphorus.—Having run into trouble with Phosphorus in our pig metal and being unable to indicate its source we

sought it in ore, flux and fuel, but like the Irishman's "flea" it wasn't there, and we were compelled to turn to the Mill Cinder. Up to this time, we, like many others, supposed that *all* the Phosphorus was "soluble," inasmuch as Mill Cinders are easily decomposable Silicates, but as we could not locate the trouble elsewhere we turned our attention to the residues which we fused and treated for Phosphorus; the results took us completely by surprise, for we found that no matter what the total amount of Phosphorus in the Cinder the insoluble residue invariably carried between 0.03% and 0.04%.

As the fusion of the residue and its subsequent treatment took more time and attention than we could give it, we had to devise a method by which we could obtain results rapidly. After some experimenting we settled on the following scheme: Weigh 5 grams substance into Platinum dish, stir up with 30 cc. H_2O, add 30 cc. HF and 30 cc. HCl, cover with platinum foil supported by platinum triangle, evaporate dry over argand turned low, add 20 cc. HCl, evaporate again to get rid of HF, add 30 cc. HCl, evaporate one-half, wash into No. 3 beaker, evaporate to syrup, add 50 cc. HNO_3, evaporate till no more brown fumes come off and liquid is syrupy, add 30 cc. H_2O, boil up, filter through 7cm filter into 16 oz. flask, wash filter twice cold H_2O, once hot HNO_3, 1.2 sp. gr., dropping acid from a pipette on side of funnel just above top of filter; wash acid out of filter. Filter retains the coke.

Boil filtrate, add $KMnO_4$ ($12\frac{1}{2}$ gms : 1000 cc. H_2O.) 'till a brown precipitate of MnO_2 separates and remains. (20-100 cc. will be required, according to the amount of carbonaceous matter dissolved and the completeness with which HCl has been driven off by the nitric acid used in the last boiling down.) Reduce the $Mn\ O_2$ with Ferrous Sulphate (free from Phos.), after reduction is complete, boil ten minutes, cool, add Am OH. conc., till the $Fe_2\ (OH_6)$ makes a thick mud, redissolve in HNO_3 conc., to clear amber colored liquid, insert thermometer, when temperature is 88° C., pour in 100 cc. molybdate (Wood's 1888

formula), shake five minutes, settle, filter off yellow precipitate, wash 2% HNO_3 (or Dudley's acid ammonium sulphate) five times. Remove acid by five washings with KNO_3 (1:1000 H_2O), determine Phosphorus by any convenient method, 1° weigh yellow precipitate 2° titre reduced MoO_3 with $KMnO_4$ 3° titre back excess standard Na OH, etc., etc. A determination by this method can be made in six hours without hurrying the evaporations with H F and HCl.

The following method has been used when not in a hurry: 5 grams in 5-in. deep dish are moistened with 20 cc. H_2O; 80 cc. HNO_3, conc. (HCl makes jelly with the silica, which encloses particles of undissolved slag and is very troublesome to handle) boil dry, ignite, till no more acid fumes are perceptible, cool, moisten 20 cc. HCl, take up in 50 cc. H_2O, filter, wash hot, HCl 1-1, cold H_2O till free from iron, ignite, fuse with 5-6 times weight Na_2CO_3, dissolve in hot, dilute HNO_3, evaporate dry, ignite till free from acid fumes, cool, moisten HCl, dry, ignite again, cool, moisten HCl, take up in H_2O, filter, boil filtrate, add slight excess Am OH, boil two minutes, filter, wash precipitate three times with hot H_2O, then wash into beaker containing original acid solution, boil down to syrup, add 40 cc. HNO_3 conc.; boil down to syrup, add 25 cc. H_2O, boil up, filter through 7 cm. filter into 16-oz. flask, wash with HNO_3 and water, precipitate and determine Phosphorus as above.

The precipitation of $Fe_2O_3Al_2O_3+P_2$ from solution of fusion freed from SiO_2 serves to get rid of the great excess of alkaline salts and leaves the Phosphorus in better condition for precipitation.

As remarked above, HNO_3 is a better solvent for Mill Cinders than HCl, as it does not gelatinize the silica and leaves the insoluble more sandy and easier filtered and washed.

Below are a few results:

Car No.	405	Soluble Phos.		.045%	Phos. by method above			.080%
"	493	"	"	.130%	"	"	"	.165%
"	3354	"	"	.800%	"	"	"	.825%
"	3354	Phos. by solution in HNO_3 & fusion of residue						.830%
"	4818	Insol. Phos.		.035%	Total Phos.		-	.155%
"	537	"	"	.038%	"	"	-	.060%

A. G. McKenna,
Secretary C. S.

Engineers' Society of Western Pennsylvania.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

Pittsburg, Sept. 15th, 1896.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the lecture room of the Society, 410 Penn avenue, Pittsburg, Tuesday evening, September 15th, 1896, President W. G. Wilkins in the chair.

The meeting was called to order at 8.25, 60 members and visitors being present.

The minutes of the last meeting were read and approved.

The Secretary here read the names of five applicants for membership approved by the Board and to be voted on at the next meeting.

Samuel Groves and John McWilliams, applicants for membership, were balloted for.

The result of the ballot showed that each candidate had received 33 votes, and they were, therefore, declared elected.

Mr. Emil Swensson. It may be of interest to the members of the Society to know how the house fund stands at present. After all bills have been paid we have $44 and some cents left. The repairing and furnishing so far done has cost about $1,050. The remaining $44 will probably be utilized in papering the halls to make them look a little more inviting.

The President. The members probably all know that since our last meeting we have lost by death our esteemed ex-President, Mr. M. J. Becker, and it would be in order for some one to make a motion to have a committee appointed for the purpose of preparing a memorial.

It was moved and seconded that such a committee be appointed, whereupon the chair appointed Messrs. Engstrom, Davison and Johnson.

THE PRESIDENT. The next business will be the reading of Prof. Fessenden's paper entitled "The Economic Use of Electric Power for Driving Tools," illustrated with stereopticon views. Mr. Fessenden being in poor voice, Mr. Ridinger will read the paper for him.

ECONOMIC USE OF ELECTRIC POWER FOR DRIVING TOOLS.

In arranging the system of power by which a factory or works is to be driven, the following things must be considered. I give them in the order of their relative importance:

1. Reliability.
2. Convenience and flexibility.
3. Cost of power.

The cost of the power I have put last for the following reasons:

From the table given below, taken from Flather's work on dynamometers, we see that, on the average, in large works one-third horse power is needed per man employed. In most works the cost per horse power per year is $50, though perhaps $75 would be nearer. (Of course, I am aware that much lower results have been claimed, but on investigation, up to date, I have always found that such statements were made either without due knowledge or understanding of the question. I have long sought for the plant of less than 500 horse power which produces its power at an average cost of less than $50 per horse power per year, including wages, repairs, depreciation, etc.)

This, then, allows $17 per man per year, and as the average wages of the employes may be taken at $600, the power cost will be one-fortieth that of the wages. If the wages be taken as 30 per cent. of the cost of production, we

HORSE-POWER—FRICTION—MEN EMPLOYED.

NAME OF FIRM.	NATURE OF WORK.	HORSE-POWER.				Number of Men.	Men per H. P.	Men per Effective H. P.
		Total.	Req. to drive Shafting.	Req. to drive Machinery.	Per cent. to drive Shafting.			
Lane & Bodley	Engines and Wood-working Machinery	58				132	2.27	
J. A. Fay & Co.	Wood-working Machinery	400	15	85	.15	300	3.00	3.53
Union Iron Works	Engines, Mining Machinery	400	95	305	.23	1600	4.00	5.24
Frontier Iron and Brass Works	Marine Engines, etc.	25	8	17	.32	150	6.00	8.82
Taylor Manufacturing Co.	Automatic Engines	95				230	2.42	
Baldwin Locomotive Works	Locomotives	2500	2000	500	.80	4100	1.04	8 20
W. Sellers & Co. (one department)	Heavy Machinery	102.45	40.89	61.56	.40	300	2.93	4.87
Pond Machine-Tool Co.	Machine Tools	180	75	105	.41	432	2.40	4.11
Pratt & Whitney Co.	Machine Tools	120				725	6.04	
Brown & Sharpe Co.	Machine Tools	230				900	3.91	
Yale & Towne Co.	Cranes and Locks	135.05	66.81	68.24	.49	700	5.11	10.25
Ferracute Machine Co.	Presses and Dies	35	11	24	.31	90	2.57	3.75
T. B. Woods' Sons	Pulleys and Shafting	12				30	2.50	
Bridgeport Forge Co.	Heavy Forging	150	75	75	.50	130	0.86	1.73
Singer Manufacturing Co.	Sewing Machines	1300				3500	2.69	
Howe Manufacturing Co.	Sewing Machines	350				1500	4.28	
Worcester Machine Screw Co.	Machine Screws	40				80	2.00	
Hartford Machine Screw Co.	Machine Screws	400	100	300	.25	250	0.62	0.83
Nicholson File Co.	Files, etc.	350				400	1.14	
	Average	346.4			38.6	818.3	2.96	5.13

have power costing three-fourths of one per cent. of the total cost. If the cost of the coal be taken as one-third the total cost of the power, we have the cost of the coal as one-fourth of one per cent. of the total cost of the finished product.

Mr. Richmond, *Engineering Magazine*, January, 1895, puts the cost lower than this: *i. e.*, at about one-tenth of one per cent., but I believe the higher figure to be more nearly correct.

If we add to the cost of production 30 per cent. for putting on the market and 20 per cent for profit, we see that the total cost of the power is a little over one per cent. of the profit, so that any possible saving in the cost of power cannot amount to much proportionately, unless the returns on the investment are much less than they ought to be in order to avoid failure in times of depression.

If now we take the fixed charges, such as salaries, taxes, insurance, interest and depreciation on plant, etc., as 40 per cent. of the cost of the finished article, then it will be seen that a shut down of half a day will cost the owner as much as the amount of his entire coal bill for nearly three months.

To the objection that this loss might be made up by working overtime, the obvious answer is that by working the same amount of overtime the same production could have been attained with a smaller plant that had no stoppages.

If we take, as an average figure, that in the total cost of the production of an article:

Material costs	30	per cent.
Labor costs	30	"
Fixed charges	40	"

and that to this must be added 30 per cent. for putting on the market, we see that anything which checks the rate of production is of the most vital importance, and *vice versa*, anything which enables work to be turned out faster is worth adopting, even at a very high first cost.

Suppose, for instance, with the above proportion, we assume that by the adoption of some new system we can increase the output by 10 per cent. What first cost should we be justified in paying for the apparatus?

Before making the change, the cost of a certain number of pieces would be:

Material	$ 30
Labor	30
Fixed charges	40
Expense of putting on market	30
Total	$130

After the change the cost would be:

Material	$ 30 00
Wages	27 37
Cost of putting on market	30 00
Total, exclusive of fixed charges	$ 87 37

Hence we would be able to pay enough for the apparatus to make the change, to raise the fixed charges per piece to $130 from $87.37, before the increased interest, etc., would counterbalance the saving. Since these fixed charges per piece are for ten-elevenths of the time it formerly took for a piece under the old system, the total fixed charges can be increased to $42.63 × 1.1, or to $46.90. In other words, if we can increase the output by ten per cent., we can afford to pay 17½ per cent. of the entire first cost of the plant for the apparatus to do it.

If we consider these facts, we see the reason why the electric driving of factories is finding so much favor. As regards reliability, an electric plant, when properly installed, cannot be improved upon. No accident, such as the unlacing of a belt or the springing of a shaft, the slipping of a belt or a loose pulley, can affect the whole plant. Even in case of accident to the engine the electric plant is better situated as it is much easier to simply start up the reserve unit than to change

the main belts of an engine-driven machine shop. Moreover, much less attention is required to keep things in order, as there are much fewer, or no, belts and pulleys to oil, and a good motor will require no attention for three months at a time, and then will only need to have its brushes adjusted and its oil bearings filled. In the case of the polyphase motors we do not even have any brushes to attend to.

As regards convenience there is no comparison.

On the screen is a view of one of the machine shops run by shafting, and considered a very good plant. As will be noted, all work has to be set in the tools by laborers. This system was used in the Baldwín Locomotive Works (a view of which I now show you) before the adoption of electricity. In one shop, where they had 40 laborers for this work and lost 10 per cent. of the time through the slow handling, the employment of electricity, (permitting the use of electric traveling cranes as shown), has reduced the number of laborers to 10 and the lost time to 3 per cent.

The doing away with the mass of pulleys and belts, dripping oil, etc., is a very considerable advantage, permitting better lighting and a clean shop, which always means better work.

In an electrically driven shop the tools can always be placed in the position best suited for them, without reference to the question whether it is possible to run shafting there. It is only a question of a very short time to make extensions in the shop, or to change the position of a tool.

Even when the shop has the tools divided up into groups, each driven by a motor through countershafting, the flexibility is still great, as the shafting for the few tools in each group is very light. View No. 3 shows a shop of this type.

Another of the advantages of the electric system is its flexibility, in that it can be applied to so many different kinds of work. On the screen is a view of a 150 ton hydraulic

press, driven by a small electric motor, thus obtaining all the advantages of hydraulic power for special purposes without having to build a whole system, and without any chance of freezing of pipes, etc.

Views 5 to 9 show the applicability of electricity to special work. 5 is in use at the Yarrow Water Tube Boiler Works for expanding tubes and is said to raise the rate of working from 70 to 240 tubes per day. There is no use for the hammer, and the mandril feeds itself.

In some shipbuilding works, instead of planing off the pecks by hand, as formerly, an electric motor is attached to a sort of lawn-mower and is run over the decks just as a lawn-mower over grass.

View No. 6 shows a portable electric pump used for transferring liquor from one vat to another.

In some of the arsenals magnets are used for unloading shot and steel billets. It is thus not necessary to fasten the material lifted, and considerable time is said to be saved.

Electric welding is now so much used that all the members of the society are well acquainted with its capabilities. In this view, however, is shown a form of welding which has its peculiar advantages, but which has not come into use in this country, as it will, no doubt, later. It is called the Bernardos system, and is especially useful for joining or putting T's on pipes, and for mending castings.

Large castings sometimes have their appearance spoiled by pieces being chipped out of them, or by blow holes. By this system such defects can be repaired and made in most cases as good as a fresh casting. The iron is melted by the arc and the metal itself is softened or melted locally and the two flow together, making a perfect union.

Nos. 8 and 9 illustrate magnetic clamps and clutches, which save much time.

These views illustrate, I think sufficiently, the flexibility and convenience of electricity.

So far, actual returns show that the use of electricity in shops increases the rate of production from ten to twenty-five per cent. It is impossible to get along at present without electricity, and now instead of having in a large works, a hydraulic plant for riveting, a compressed air plant for cleaning castings, and for hoists and blowers, a gasoline plant for lighting, steam plant for power and on cranes, and any amount of shafting, we may have but one power house from which everything is driven. Moreover any machine or department can be shut down without affecting the rest of the shop, which effects a great saving when part of the plant is working overtime.

To consider now the subject of cost. It was pointed out when we were considering the subject broadly, that the question was after all but a small one. Yet it must be remembered that every little counts, and so we will consider this point more in detail.

First comes the question, "How much of the power is wasted in friction in shafting, in an ordinary shop?" From the table given by Flather (above), we see that the answers he received differ greatly, varying from 15 per cent. in the case of the Fay Co. to 80 per cent. in the case of the Baldwin Locomotive Works. The average given as the result of these returns is 38.6 per cent.

The former I cannot help thinking must be too low, and the latter I think must have been sent the author by Mr. Vauclain just after he had received a very heavy coal bill. The average is 38.6 per cent., or neglecting the figures for the Baldwin Locomotive Works, 34 per cent. I fancy that in the case of the Baldwin Locomotive Works the effect of steam condensation in the pipes was included in the losses.

Henthorn gives the average in New England cotton mills from the result of 55 tests, as 26 per cent. Flather estimates at from 30 to 40 per cent.

Let us take an imaginary shop, 300 ft. long and 220 ft. wide. Suppose it run by a main shaft and countershafting,

the speed of the secondary belts being 660 ft. per minute on the average, and the average weight of the shaft and pulleys and belts 3 times that of the shafting alone. Then, taking into account the tension of the belts, and assuming that the pulleys are all well oiled and the shafting in perfect alignment, we get for the power lost in the friction, 20 per cent. of the total power which the shafting can transmit. This is lower than the results given above, first because it assumes theoretically perfect conditions, secondly because it does not allow for more than one line of countershafting whilst in most works run by shafting there are several transmissions.

We will therefore take the average of all observed results, i. e., 32 per cent., as correct on the average, though the inclusion of the New England mills reduces the average somewhat.

It is to be noted that this is the per cent. lost of the *total* power capacity, and *not* of the *average* power.

Let us see what this will amount to.

In a large machine shop, if we run it by shafting, we must install a shaft strong enough to run all the machines. (This is for the reason that there is this great difference between mechanical transmission and electrical transmission. A shaft breaks down when it is loaded beyond its torsional strength whether that torsion lasts for one minute or for ten hours. When it once gets beyond its limit it goes almost instantaneously. In an electric motor, however, the reason why its capacity is fixed at a certain rate is because if run continuously above that rate it will heat too much. The effect is therefore a cumulative one. If it can run with 10 horse power continuously it can stand 15 horse power for five or six hours, 20 horse power for an hour and 50 horse power for a few minutes, depending of course upon the machine. Consequently the shafting put in depends upon what the maximum load is, while the motor put in depends upon how long the maximum load lasts and what the average load is.)

In this shop many of the tools will be idle for from 30 to

70 per cent. of the day, on account of the time taken to adjust the work, and the fact that some of them may not be needed at all. Again, even when running, a good deal of the time they are not worked up to their maximum capacity but are taking lighter cuts and slower speeds that they are capable of. The average power must therefore be much less than the maximum.

The average load on a steam engine is very hard to get, over any long period. Tests on three engines taken by myself, from the water consumption per day, give about 50 per cent. as the average load.

If then, in our imaginary shop we have an engine capable of standing continuously the maximum load, which we will take as 200 horse power, we will find the engine delivering on the average only 100 horse power to the main pulley.

200x32 will be the loss in friction in the shafting, leaving 100–64 as the power actually used. The efficiency will then be 36 per cent, and the per cent. of the power lost in the shafting 64 per cent.

Actual tests made show a variation between 50 per cent. and 80 per cent. The mean of the tests taken on 108 shops gives for the average loss through friction as 69 per cent.

It has been stated by some engineers that the maximum losses in shafting are smaller than those necessitated by the losses in dynamos, motors and lines in electric transmission. On the other hand it has been repeatedly demonstrated in practice that the adoption of electric driving saves about 30 per cent. of the fuel bill. This I think explains the discrepancy—the fact that the friction losses are practically the same at light as at full loads, and form of course a much larger percentage at light loads.

I do not of course pretend that these figures apply to all cases. They are merely averages. I believe that in the Pencoyd Iron Works, for instance, the average load is only from one-fifth to one-sixth the maximum, and I understand that at the Carnegie Homestead Works it is often about one-sixth.

Our general result is then, that if the shops were always run at full load the engine and countershafting would probably be more economical, though less convenient than the electrical method, but that in view of the fact that the maximum load is only on for brief periods while the friction losses in the countershafting are constant, the electrical method has a large margin to work on under average conditions.

We will now take an estimate of the cost of equipping our imaginary shop in five different ways:

A. Engine and countershafting.

B. Electric motors driving large groups of tools.

C. Separate electric motor to each tool.

D. Electric motors driving groups of about five tools.

E. Tools driven by individual motors capable of standing large overloads, driven by engines and dynamos capable of being largely overloaded.

We have 130 horse power required to drive the tools, not including friction outside tools, excepting that of the belting from countershaft to tools; 64 horse power is lost in friction of shafting, therefore we shall use altogether at maximum load 200 horse power. The average load will then be 100 horse power, and the average horse power of tools in use 36.

In case "A" we need, therefore, one 150 horse power engine, 200 horse power of boilers, shafting, belting, hangers, etc. The first two items, with building, stack, foundations and all fittings will come to about $14,000; the third item to about $6,000, making a total of $20,000. To this should be added $3,000 for the additional strength of structure required to carry the shafting, making a total of $23,000.

In case "B" we have, as before, 36 horse power of tools in use on the average. A large number of experiments, including those by Mr. Lufkin and the New York Edison Co., show that the average friction loss in large groups of tools is about 70 per cent., of which possibly 20 per cent. is lost in the motors and 50 per cent in shaft friction. This is about 10

per cent. less than the friction loss in engine driven main and countershaft driven shops, and is, no doubt due to the absence or short length of the main shaft. We will need in this case an average load on the dynamo of $36 \times 10 \div 3$, or 120 horse power, which is thus greater than that of the first case. Our maximum load will be about the same, or a trifle larger, to make up for the loss in the dynamo. We thus need: Two 80 horse power engines, 200 horse power of boilers, two 80 horse power dynamos, 120 horse power of motors capable of standing 50 per cent. overload. The first two items will come to $16,000, the second to $7,200, the third to $6,000, and shafting to $2,000, making a total of $31,200. It will thus be seen that this system is not only higher in first cost but is more inefficient than the first one, where the shop is driven by engine and countershaft.

This shows that it is possible by forming the tools into too large groups, containing, say, more than ten machines in each group, to do away with many of the advantages of electric transmission.

In case "C" we have a separate motor to each machine. Taking as before our average horse power of tools as 36, we must have motors for 80 horse power, capable of standing 50 per cent. overload, because we can no longer take advantage of there being an average load on a number of tools as we can in the group system. Each motor must be able to take care of the maximum load of its tool. Since the loss in the motor will not be greater than that between the countershaft and tool, we shall need, including loss in dynamo, 100 horse of power engine and boiler, 90 horse power of dynamos, 80 horse power of motors and gears. The first item will cost $8,500, the second $4,500, the third, $6,000. Total, $19,000.

We see here that we have increased our cost for motors in two ways—by using smaller motors and a greater horse power of them. But we have greatly decreased our generating plant.

through doing away with the loss in shafting, and we have no expense for shafting, belts, etc.

"D." It is evident that if we could combine the advantages of "B" and "C," without their disadvantages, we should be better off. Suppose we could run the tools in groups of five with a loss of only 10 per cent. for shaft friction, and that this grouping would enable us to use motors capable of dealing only with the average load. We should then need one 110 horse power engine and boiler, a 100 horse power dynamo and 40 horse power of motors, and shafting. These would cost respectively $9,350, $5,000, $3,000, $1,000, or a total of $18,350.

"E." A still better showing would be made if we could get motors and dynamos to carry large overloads for a long time, say by means of fans attached to the armatures. What the efficiency would be at the larger loads is not a matter of much consequence, as the heavy loads would not occur very often. It might drop to 40 per cent and do little harm. With such motors and dynamos we would need one 100 horse power engine and boiler, one 50 horse power dynamo and 40 horse power of motors The cost of the items would be about $8,500, $2,500 and $3,000. Total, $14,000.

We see from this what an important thing it is that motors and dynamos for machine shop work should be capable of standing large overloads of, say, three times their rated capacity. This is the next point where advance should be made, and when we get it we shall no doubt see the individual motor system adopted entirely.

A rough estimate of the running cost of these five plants, which I believe is fairly correct, is as follows:

"A."

Interest and depreciation	$3,200
100 horse power at $20	2,000
Wages	1,800
	$7,000

"B."

Interest and depreciation	$4,480
120 horse power at $18	2,160
Wages	2,000
	$8,640

"C."

Interest and depreciation	$3,040
45 horse power at $20	900
Wages	1,800
	$5,740

"D."

Interest and depreciation	$2,776
50 horse power at $20	1,000
Wages	1,900
	$5,676

"E."

Interest and depreciation	$2,200
40 horse power at $20	800
Wages	1,800
	$4,800

Considering the fact which I have emphasized, that what we need is machines which are efficient at average loads, and capable of standing heavy overloads no matter at what loss of efficiency, we see that as we cannot at present get such machines, we must use dynamos, motors and engines which have a high efficiency at low loads.

The characteristic should be shaped as shown in figure 1, which represents the efficiency characteristics of two dynamos. Fig. 2 shows the equivalent curves for two classes of steam engines. It will be seen that in each case the machine which has the higher efficiency at full load would give the poorer

results in practice as it is less efficient at average loads. Curve 3, Fig. 3, shows the better engine coupled to the better dynamo; curve 1 shows the other two. Curve 2 shows the better dynamo coupled to the poorer engine (which I may say is only poor for this work,—it is a condensing Corliss).

It will be seen what a bad effect the engine has on the dynamo. This is the reason why the Corliss engine gives such poor results in many classes of electric work, while for cases where the load is fairly uniform it can hardly be excelled. All three machines—engine, dynamo and motor, must have their characteristic curves carefully chosen if the best results are to be obtained.

What the size of the group of tools driven by one motor should be will depend upon circumstances. If the group be too large we loose in shaft friction, and so increase our coal bill and first cost for generating plant. If the group be too small we loose the advantage of the fact that the group will require an average power much less than the maximum, consequently we increase our first cost for motors and decrease our bill for power and generating plant.

The views now thrown upon the screen show different electrically driven apparatus, electric dynamos and motors, and the methods of constructing them, and a view of the power plant of the Westinghouse Machine Co.

GENERAL RESUME.

We have in general these results:

1st. Were the tools always fully loaded, the method of driving by engine, main and countershaft would be more efficient than the electrical, though even then the great convenience and the increase in production through the doing away with shafting would probably render its installation advisable.

2d. If we form our tools into too large groups we loose almost all the advantages of the electric system.

3d. The best size of groups is probably small.

4th The production of motors and dynamos, capable of standing overloads of three times the normal capacity would give a system not only more efficient and convenient but also less in first cost.

5th. The dynamos, motors and engines must have their characteristic curves carefully chosen if the best results are to be attained.

I have to acknowledge my indebtedness to Mr. Ridinger, who collaborated with me in this paper; Mr. Scott, of the Westinghouse Electric and Manufacturing Co.; Mr. Bole, of the Westinghouse Machine Co.; Mr. Cox, of the Crocker-Wheeler Electric Co., and to a lesser degree to a number of other gentlemen. I have also drawn freely on the reports of the various institutes and technical journals with a view to supplementing what data I had obtained from my own experiments and tests.

DISCUSSION.

THE PRESIDENT. From the number of strange faces present this evening I should judge that there are many electricians here who desire to discuss this paper. I would like to ask Prof. Fessenden one question. I notice by the papers lately that in the Pullman shops at Pullman, Illinois, they have introduced compressed air for motive power; do you know whether or not they investigated electricity, and why they adopted compressed air instead of electric power?

PROF. FESSENDEN. No, I do not know. There may be some peculiar circumstances which render its use advisable there. I know that the compressed air system which has been so long used in Paris has now been abandoned in favor of electricity, and I am at a loss to know what advantage Mr. Pullman will get from it.

MR. SCOTT. You have called upon the electricians for a discussion of this subject. It seems to me that the electrician

has said enough, and it is the mechanical man and the mill man who ought to speak now. Electricity comes to their aid as a means of distributing and applying power. Three or four years ago it was largely theoretical, and was looked forward to as a new method of operating mills and factories, but a large part of this evening has been taken up in illustrating what is now actually being done. It has been but a very few years since the first motors were put to work in this vicinity merely as experiments, or in special places, but now many of the plants about Pittsburg are using electricity some to a limited and others to a considerable extent. Several manufacturing concerns are depending entirely upon electrically transmitted power. Steam does not enter the machine shop and factory for power purposes. The steam plants are in separate buildings, and the power is conveyed from them entirely through the agency of the electric plant. The flexibility and practicability of this has been well set forth in the carefully prepared paper read here this evening, and it seems to me that the question is one for the mill operator and mechanical engineer. Does this electric system meet the requirements for mill work? Have the claims of flexibility, efficiency and economy been properly made? Wherein does the electric system fail to meet the requirements for mill work? The challenge has been given from the electrical side; their position has been stated; wherein does the system fall short?

THE PRESIDENT. Are there no mill men here to give us the results of their experience?

J. P. JOHNSTON. I am not an electrician, so I would like to ask the Professor a question for information. My attention has been called to this; that after the lights have gone out in a house—the armature burned out—it must be very expensive, and I would like to ask the Professor if he has figured that in his economy—such a contingency as that?

PROF. FESSENDEN. That would be annoying of course, but such things do not occur in a well laid out plant. I know

that was one experience some of us have had in the earlier days of the business, but now there is no excuse for such occurrences. In the first place you have the plant divided up into units which you group together, and if one unit breaks down you have the rest to carry on the load.

The power should never be interrupted with good management. With the new types of winding a burn out costs very little to repair, as you simply slip off the burnt coil and slip on a new one.

G. H. WINSLOW. As to the going out of the lights and the burning out of armatures, I think it is due to the fact that economy is being considered. They endeavor to keep the expenses down to the lowest notch and any revenue is increased as fast as made. The result of it is that the machines are overloaded as much as possible and finally a little more than they can stand and they then give way.

J. P. JOHNSTON. The Professor did not state whether or not he figured that allowance in his economy.

PROF. FESSENDEN. Yes, I allowed 10 per cent. on the cost of the plant; that was included. I believe 10 per cent. is too large, but I took that to be on the safe side.*

A MEMBER. I noticed in a recent publication that experiments have been conducted in the Baldwin Locomotive Works to ascertain the power required to drive different machine tools by electricity, and the result was far in excess of the power supposed to drive the different sizes, and I would like to ask the Professor if he has made any such tests, and what his experience is?

PROF. FESSENDEN. My experience has been that the average power required to drive tools has been greatly overstated, and we really never know how little tools took on the average till we began to use electric power. As a general rule,

*The statistics from a number of central stations show that the annual repairs to dynamos amount to very nearly one-third of the annual repairs to engines, or to about two per cent. on first cost of dynamos.

by comparing measurements in some 70 odd plants, the power required is only $\frac{1}{3}$ of that ordinarily looked upon as the power necessary. As to the Baldwin Locomotive Works, of course their work is heavy. I do not know that the power used is much larger than it should be.

Mr. Bole. As bearing on the amount of power which ordinary machine tools will require, I can state that this afternoon I counted 44 machine tools on our second floor run by one 20 horse power motor. The largest tool being a 13-inch slotter and the smallest one an ordinary drill press. These tools use belts ranging from 4-inches down to $2\frac{1}{2}$-inches in width.

The experiments of the Baldwin Locomotive Works as to the amount of power required for their tools have received a great deal of attention, and I have heard the subject mentioned on a great many occasions.

In our new works we are using motors; in our old works we used steam engines. We do not find it necessary to furnish anything like the power for the tools that the Baldwin tests showed. The indications are that the Baldwin people wanted to make a good showing and by taking the highest readings of voltmeter and ammeter and multiplying them together they made the horse power as great as possible.

At our old works we formerly required about $1\frac{3}{4}$ horse power on the average of all our tools from the largest down to the smallest.

In case of 40 tools a great many are idle at one time. The workmen are taking out work, gauging work, and doing other things not requiring power.

By grouping a considerable number of tools, and driving them by a common line shaft, from one motor, advantage can be had in the general average of power consumed.

Prof. Fessenden. I have the tests of the Baldwin Locomotive works here, and see that the figures given for the power taken are large. This however is no disadvantage, provided

the power taken does useful work; in fact it is an advantage, as the more work it does in a given time, the better.

Now on looking over the figures given I find that those machines which take such abnormal power, spend it almost entirely on the work. For instance the 63-inch lathe takes 2-4 horse power running idle, and takes 10-2 when taking the maximum cut. Hence the efficiency of the combination is 75 per cent. which is a remarkably good showing. In other words, three-fourths of the power put into the motor is spent in actually cutting off metal.

Consequently, if these measurements are correct and represent what the tool is capable of standing continuously, the Baldwin people are many thousands of dollars in pocket since they have practically more than doubled the capacity of their plant. For, if by putting on an electric motor we find that the tool can be driven so as to take twice the power and that, as is shown in the Baldwin tests, all that additional power does useful work in turning off metal, then we have simply got the value of two tools at the price of one, and moreover are cutting down the cost of labor as well.

Mr. Scott. I have been considering this evening the change that has taken place in two plants that have been recently reconstructed, the Westinghouse Machine Co. and the Westinghouse Electric and Manufacturing Co. Three years ago the Electric Co. was operated by Westinghouse steam engines. The plant on Garrison alley was supplied with engines located about at different places, something like 20 engines were scattered around every place through the various departments and on different floors, taking steam from one, and at a later time, two sets of boilers. The plant has been reconstructed and removed to East Pittsburg and is now operated by electricity. The Westinghouse Machine Co., which builds engines of high economy, has also built a new factory which has electric motors distributed all through it for driving its cranes and machinery, with a steam plant in a separate build-

ing outside, so that instead of the electric plant being operated by steam engines, the steam engine factory is now operated by motors.

(Mr. Ridinger here explained two tracings hanging on the wall.)

Mr. Bole. The upper picture I recognize: It represents a large modern factory in which all the shafting in all departments are driven by one central engine. I would like to call attention to the strength and stiffness of building required in order to carry shafting ranging as high as 6 inches in diameter for transmitting 200 to 300 horse power for a distance of 600 or 800 feet You can run an electric wire where you cannot take a great shaft.

Mr. Swensson. I would like to ask if motors of to-day are of as delicate construction as those built about five years ago. We have several ordinary jib cranes, which about five years ago were fitted up with 8-ton motors, the same being operated by common labor. These motors are giving us continual trouble by getting out of order in some part or another, the repairing of which occupies the entire time of two electricians.

Mr. Bole. I know from my own positive knowledge that motors and generators built now are very much more durable. Five years ago, when you put in those motors, electricity was in its experimental stage. Great strides have been made in its development since then.

Mr. Lewis. For Mr. Bole's information I would say, that instead of the structural engineer having to provide for carrying and keeping shafting in line, he is now busy with the support and bracing of high speed cranes which travel bodily at 200 or 300 feet per minute, with a trolley which racks back and forth at 200 feet or more per minute, and which carries live loads of 30, 40 and 50 tons. It is not extravagant to say that the weight of buildings per square foot covered has been doubled in providing for the new order of things.

Mr. Swensson. I know of a charging machine weighing about 48 tons that travels 500 feet per minute, and, in fact, mill buildings containing electric traveling cranes are to-day made considerably heavier than any similar old building with shafting and jib-crane.

Mr. Bole Well, there can be no comparison between the strains thrown on a building by a jib crane and those imposed by a traveling crane if you deal with the same speed factor. Now-a-days when we put up a traveling crane we do not think of driving any other way than electrically.

It is possible by this means to transmit large powers and lift heavy weights and thus to do a great deal more work than by any other means which will necessarily throw a heavy strain on the building, but when the building is properly designed the outcome of the whole thing cannot be anything else than satisfactory. My point as to the shafting is this, When a man puts up a line shaft of large diameter, the shaft itself is not flexible, and it must necessarily have an inflexible building to carry it. Otherwise, there must be a tremendous amount of friction and much waste of horse power, making the journals hot.

A vote of thanks was then tendered Prof. Fessenden for his able and interesting paper.

Adjourned.

Daniel Carhart,
Secretary.

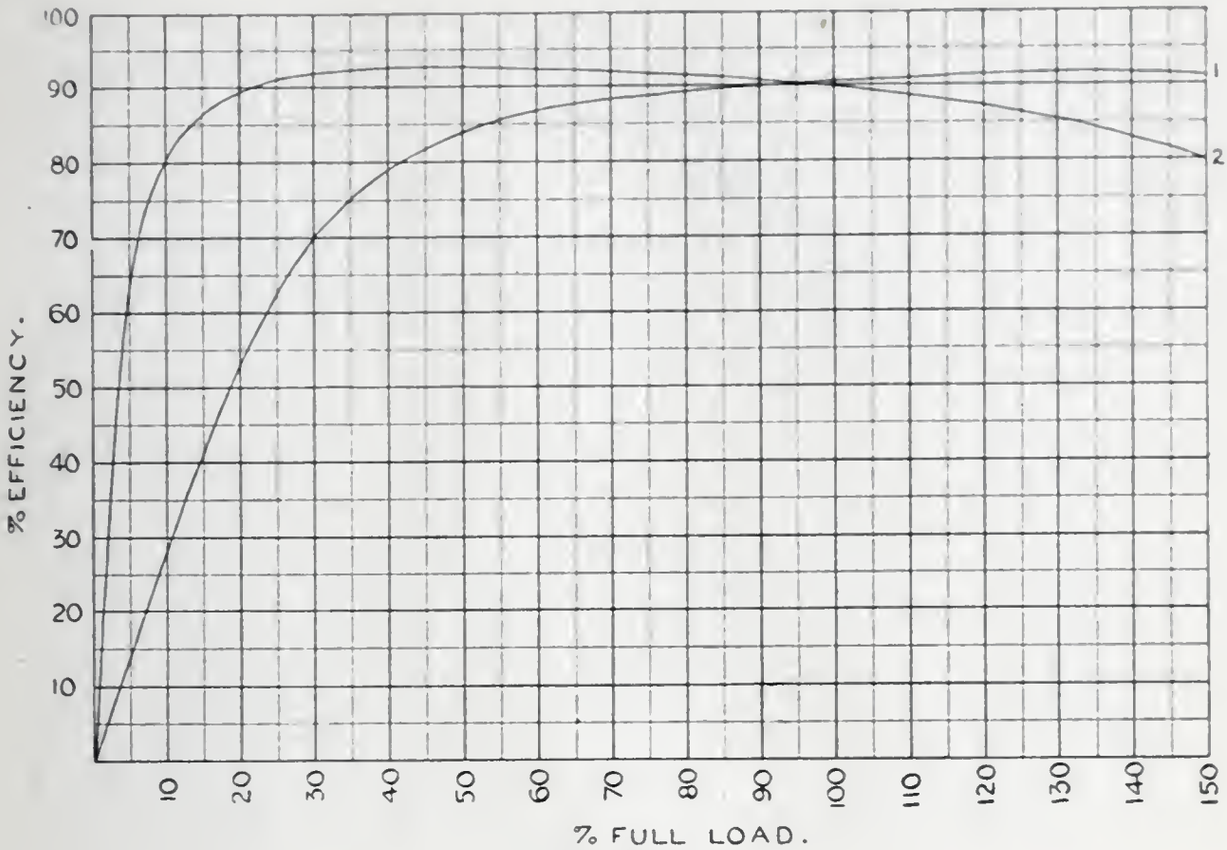


Fig. No. 1.

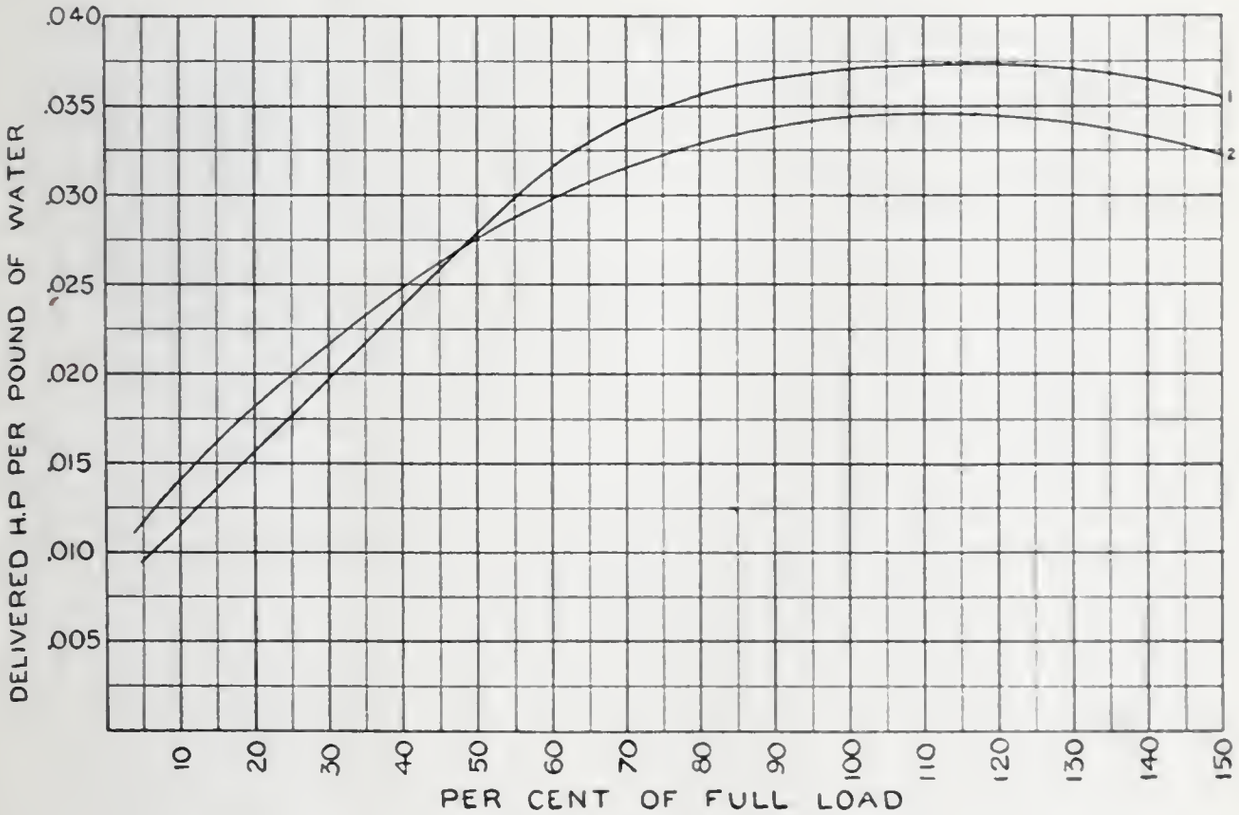
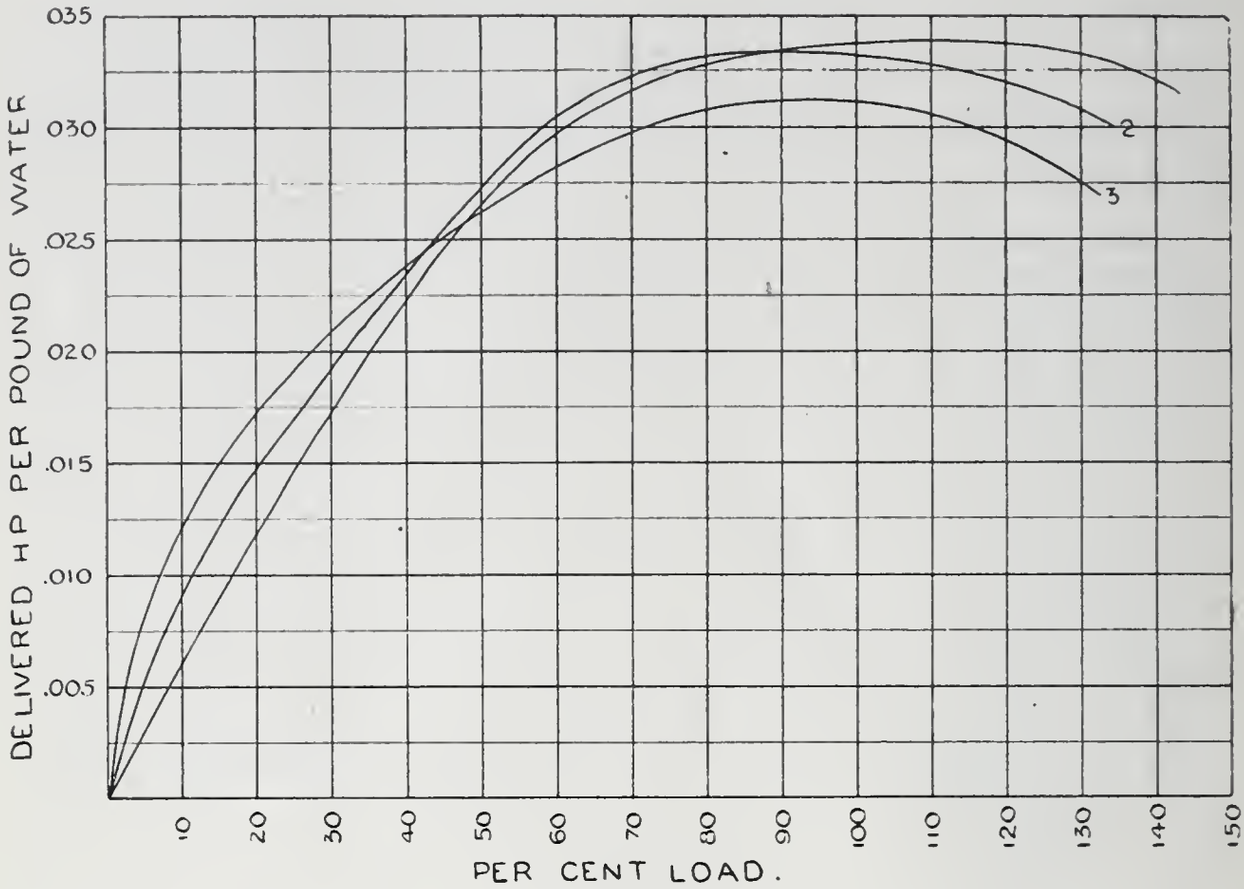


Fig. No. 2.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PER CENT LOAD.
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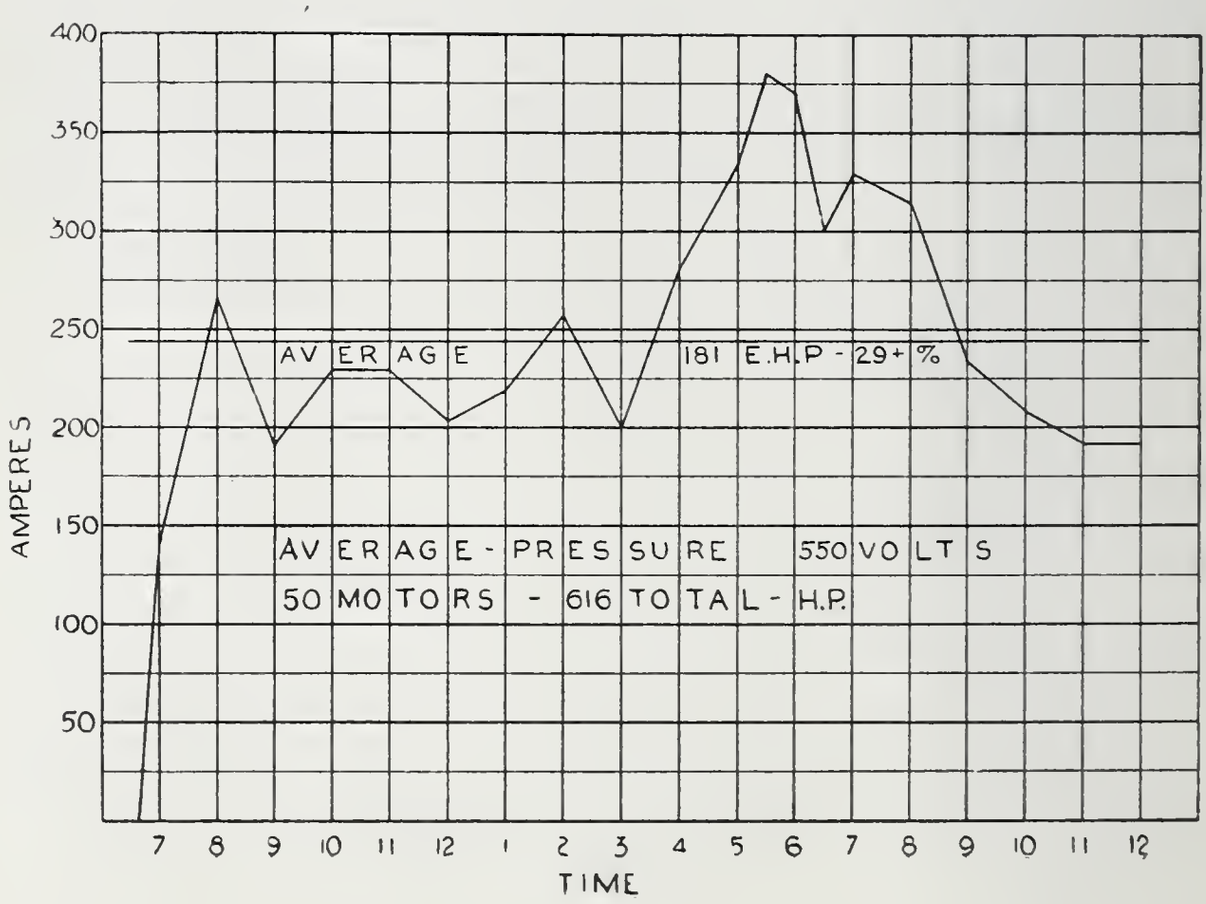
Fig. No. 3.


AMPERES
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AVERAGE 181 E.H.P - 29+ %
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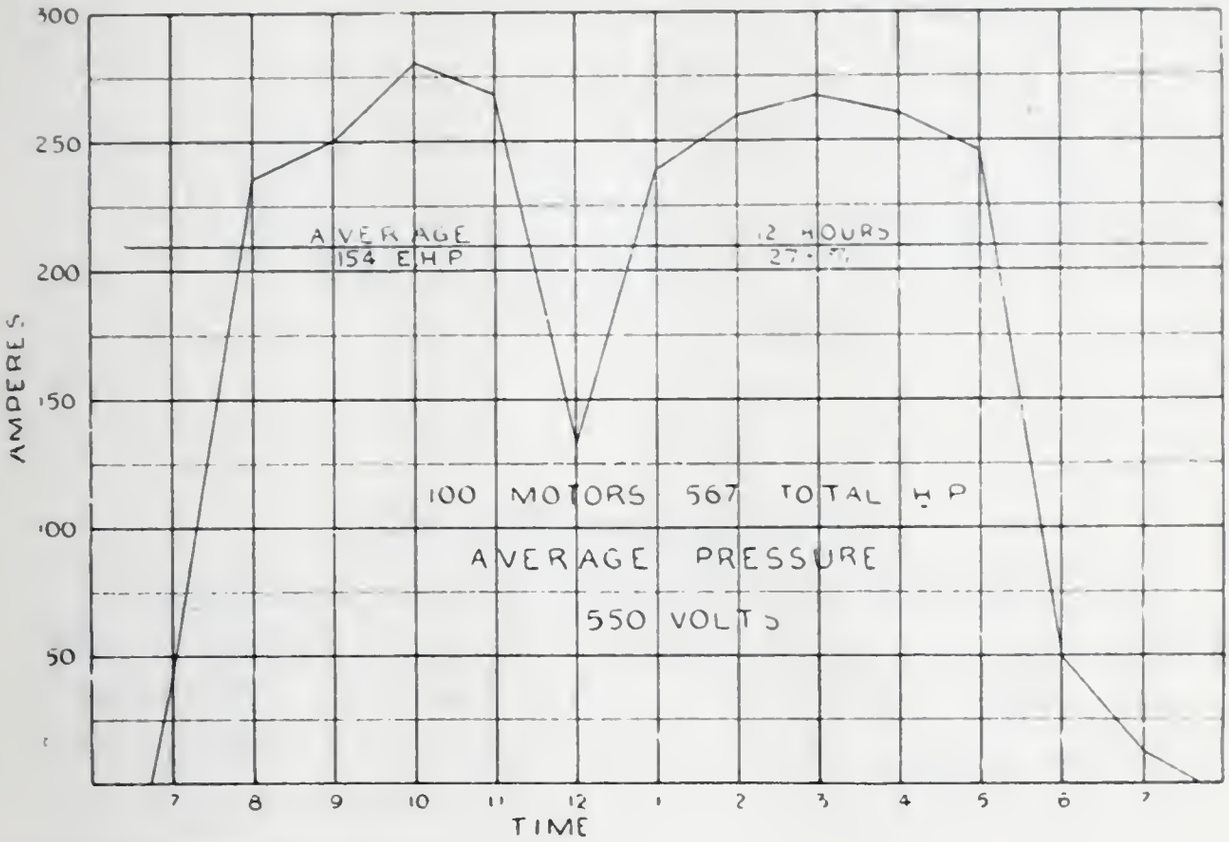
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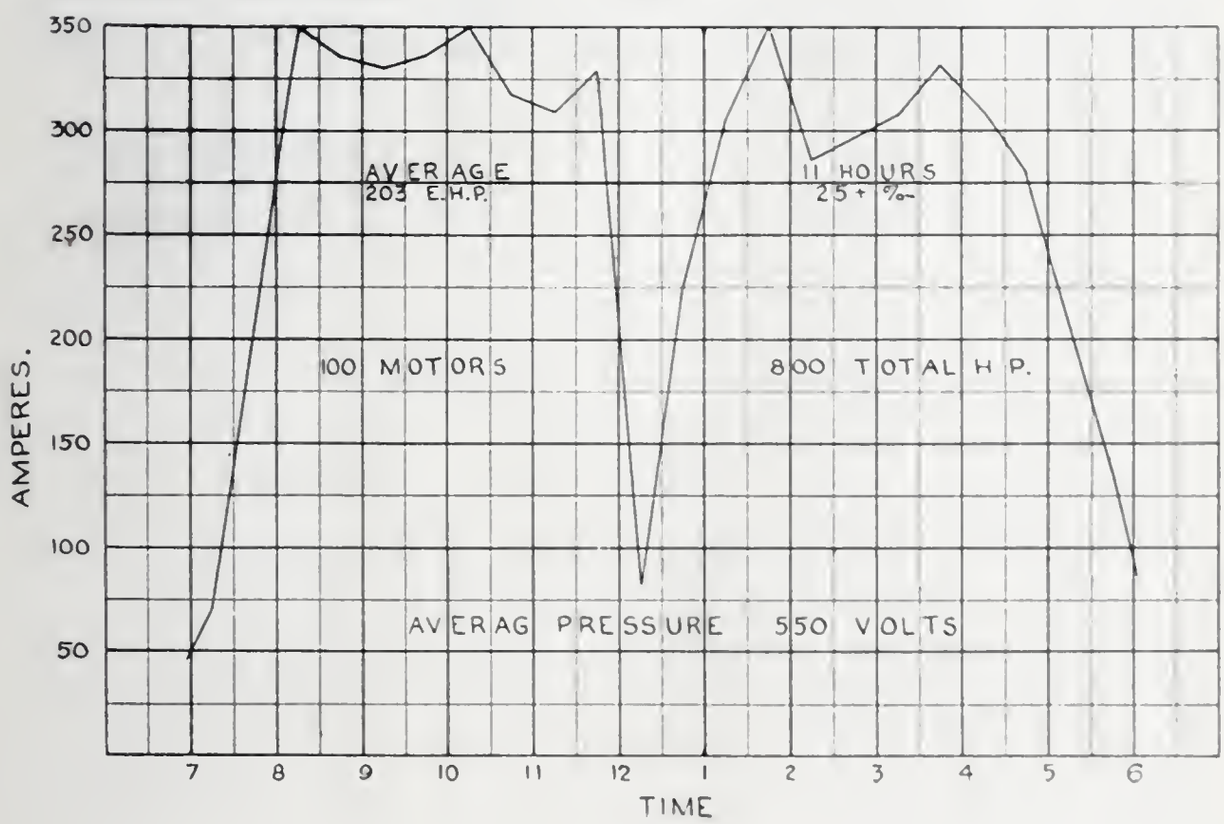
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AVERAG PRESSURE 550 VOLTS
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TIME

CHEMICAL SECTION.

The Chemical Section of the Engineers' Society of Western Pennsylvania, met September 17th, at the Society's rooms, 410 Penn Ave. Mr. J. M. Camp in the chair. The minutes of the last meeting were read and approved. A letter from Mr. R. B. Carnahan was received stating that owing to press of business he was unable to be present with the paper set for the evening, but would read it at a later meeting of the Society. The remainder of the time of meeting was taken by informal reading and discussion of topics from recent numbers of the leading Chemical Journals. The meeting adjourned at 10 P. M.

A. G. McKenna,
Secretary.

XV.

METHODS FOR THE ANALYSIS OF ORES, PIG IRON AND STEEL IN USE IN THE LABORATORY OF THE OHIO STEEL COMPANY, YOUNGSTOWN, OHIO.

BY J. C. BARRETT.

DETERMINATION OF SILICIA IN ORES.

Weigh off 5 grams ore which has been dried at 100°, dissolve in 75 cc. strong HCl, evaporate to dryness, add 30 cc. strong HCl, and when dissolved dilute and filter, washing with dilute HCl and water. The residue is then burned and fused. The fusion is dissolved in water, made acid with HCl, and evaporated to dryness. Take up with HCl and water, filter and wash well with water. Put in crucible wet, heat gently until dry and the paper well charred, then heat in a muffle until white. Weigh as soon as cold. Observe precautions for $Ti\ O_2$ and $Ba\ SO_4$.

DETERMINATION OF IRON IN ORES.

The ore is dried at 100° for 1 hour and cooled in an exsiccator. Weigh quickly five grams of the ore, dissolve in dish with 75 cc. conc. HCl, evaporate to dryness on sandbath. Redissolve in 30 cc. strong HCl, and when all is in solution evaporate to a very small bulk or near sticking point. Dilute with hot water, filter, washing with as little dilute HCl as possible. Wash well with hot water. Burn silicious residue and, if colored any with iron, fuse. Dissolve and make acid with HCl and evaporate to dryness to separate the SiO_2. Take up with as little HCl as possible and filter into main solution, which should be in a graduated 500 cc. flask, which has been calibrated accurately with a 100 cc. pipette. Keep at temperature of room and fill with water of same temperature to

mark, mix well. Take 100 cc. with same pipette you have checked flask with and put into a clean flask of 500 cc. capacity, fitted with a gum cork having a Bunsen valve. Add 100 cc. of 1 to 4 H_2SO_4, and then 15 grams of zinc. Keep cool for a time, then add 10 grams more of zinc if necessary. When all action is over raise to a good heat, but not to boiling. Cool, pour into a No. 5 beaker into which 50 cc. of H_2SO_4 (1:4) has been poured and wash out flask well, decanting from residue from the zinc, filling beaker to a little more than half full, and titrate with standard solution of $KMnO_4$, making allowance for a blank on zinc which is carried along side by side with the ore, using the same weight of zinc in blank as for ore. In presence of titanium reduce with sulphuretted hydrogen. Remove the sulphuretted hydrogen and titrate.

DETERMINATION OF PHOSPHORUS IN ORES.

Dissolve 5 grams ore in 75 cc. of strong HCl and treat in the same way as for iron, except that there is added a little HNO_3 on the first evaporation. When the second evaporation reaches sticking point add 3 or 4 drops HCl, dilute and filter into 16 oz. flask, wash and then burn the residue and fuse. Dissolve the fusion in water, make acid with HCl, and evaporate, take up with as little acid as possible, dilute with H_2O and filter into the flask with first solution. Add 25 cc NH_4OH, then 25 cc. conc. HNO_3 which should just redissolve the precipitate and leave the fluid slightly acid. Heat the solution in flask to 85° exactly, and add 75 cc. Molybdate of Ammonia solution and shake for 5 minutes. When it has stood for one-half hour, or until settled, filter through a 9 cm. Munktells' paper, which has been dried for 1 hour at 110° and weighed between watch glasses, as soon as taken from oven. In presence of As. or Ti. I follow Blair's acetate method after I get the main filtrate and that from the fused residue united, down to the basic acetate ppt. carrying the Phosphorus. This is put into a small beaker, paper and all dissolved in a mixture

of dilute HNO_3 and HCl, warming the beaker with its contents. Filter from paper and evaporate to expulsion of HCl, now filter into a 16 oz. flask and precipitate Phosphorus as above with Ammonium Molybdate solution at 85°. When necessary or desirable the yellow precipitate and paper are put into a small beaker, treated with dilute NH_4OH, the paper and silica separated and phosphorus precipitated with magnesia mixture.

The yellow precipitate is washed well with 2 per cent. HNO_3 solution, excess of moisture removed with blotting paper and dried in an oven at 110°, taking from oven and weighing at once between the watch glasses.

The Ammonium Molybdate solution is made by dissolving 200 grams MoO_3 in 500 cc. water with 500 cc. NH_4OH, and adding 2500 cc. of HNO_3 of 1.2 specific gravity, and keeping in a warm place for 24 hours.

DETERMINATION OF MANGANESE IN ORES.

Dissolve 5 grms. ore in 75 cc. conc. HCl, evaporate to dryness, take up with HCl and when in solution evaporate to a small bulk. Filter into a 500 cc. flask. Burn residue after washing, fuse, dissolve fusion in water, make acid, evaporate to dryness. Take up with a small quantity of HCl and dilute with water, filter into main solution. If little manganese is present, evaporate the whole in a No. 4 beaker to sticky point with conc. HNO_3 twice. If manganese be in large quantity, fill flask to mark and take a measured quantity after shaking up well, and evaporate as above. Then add 100 cc. conc. HNO_3, heat to boiling and precipitate MnO_2 with $KClO_3$ and boil for a few minutes. Remove from lamp and cool. Filter through asbestos filter and wash once with colorless HNO_3. When dry, transfer asbestos and precipitate to original beaker and wash filtering tube with conc. HCl and hot water, washing down sides of beaker with same, using about 18 cc. HCl. Heat, while shaking, over a lamp until MnO_2 is entirely dissolved. Filter off asbestos receiving so-

lution in a 16 oz. flask. Wash well and make a basic acetate precipitate. Filter from this precipitate into a No. 6 beaker. Redissolve the precipitate with HCl and repeat the basic acetate, filtering into the original solution. Make solution in beaker acid with acetic acid, heat to boiling and precipitate Mn. as phosphate with ammonium phosphate; boil until the ppt. is crystalline, stirring if necessary, then add 25 cc. NH_4OH, boil for a few minutes, remove from light and when settled filter and wash with water about five times. Absorb excess of water on blotter and put precipitate in crucible. Char with lid on, then remove it and burn white. Weigh as $Mn_2P_2O_7$.

Use precautions for lead or barium.

DETERMINATION OF SILICON IN PIG IRON.

Weigh off .9404 gram of iron, dissolve in 25 cc. of a mixture of 28 parts of HNO_3 of 1.2 specific gravity and 12 parts of dilute H_2SO_4 (1 part water to 1 part acid). As soon as solution is complete, evaporate over burner. Use a 4½ inch evaporating dish. When dry, raise the heat until copious fumes of SO_3 escape. Cool, add a few cc. of dilute HCl (3 acid to 5 water) and 25 cc. of hot water. Replace over lamp until solution is complete. Filter, wash paper once with hot water, then once with dilute HCl, and three or four times again with hot water, absorb excess of water from paper and residue with blotting paper. Place in crucible and burn in muffle, cool, weigh and divide by 2. Result = silicon.

DETERMINATION OF SULPHUR IN PIG IRON AND STEEL.

Evolution Method.—Weigh 5 grams, place in a 16 oz. flask, closed with a funnel tube and exit tube for gas which is connected with a tube extending to the bottom of a 1 inch by 10 inch test tube. This test tube is filled two-thirds full of a cadmium chloride solution. In the bottom of the tube is placed about 1 inch of ammoniacal solution of cadmium chloride. (This is made by dissolving 100 grams in 500 cc. water and adding 500 cc. NH_4OH; filter into a 2 gallon bottle and add enough water

to make 3000 cc. and enough NH_4OH to make 5000 cc.) After adding 1 inch of this cadmium chloride, fill tube with water to two-thirds. To drillings in flask add 80 cc. dilute HCl (3 acid to 5 water), place over argand burner and heat until quite warm; lower light until solution is complete then turn up light until steam drives all gas from flask. Disconnect flask and pour solution from hot tube with the yellow sulphide into a No. 4 beaker. Wash out tube with water and enough acid (dil. HCl) to make solution in beaker acid and dissolve the sulphide. This is titrated immediately with a standard solution of iodine which has been standardized with a sulphur standard so as to read percentage. Each 0.1 cc. = 0.001 sulphur. While titrating take time and see that all sulphide is dissolved. In titrating the beaker should be two-thirds full.

Aqua Regia Method.—Weigh off 5 grams, place in a No. 4 beaker, add a mixture of 5 cc. strong HCl and 40 cc. strong HNO_3 to drillings at once. Heat until solution is complete, add 40 cc. strong HCl, transfer to a No. 2 beaker or 4½ inch dish, and evaporate to hard dryness. Do not burn. Cool, add 30 cc. HCl (strong), dissolve and evaporate to formation of a crust, add 10 or 12 drops of HCl, dilute and filter into No. 2 beaker. Wash well and fill beaker three-fourths full, heat to boiling and precipitate with 3 cc. $Ba.Cl_2$ solution (25 grams to 500 cc. water). Let stand over night on warm plate or sand bath, then evaporate to formation of scum, add a few drops of HCl and dilute with water to about one-half beaker full, evaporate again to scum, add a few drops of HCl to redissolve and dilute to two-thirds full with cold water and let stand at temperature of room over night. Filter through a double filter No. 589, 7 cm., wash well with HCl and water, burn in open crucible. Purify this precipitate if necessary.

DETERMINATION OF PHOSPHORUS IN PIG IRON AND STEEL.

Dissolve 5 grams in 4½ inch dish, using 60 cc. of 1.2 HNO_3 for steel, and 70 cc. for pig iron. When solution is

complete, which will be in a few minutes for steel and in about 20 minutes to half hour for pig iron, evaporate over Argand burner with watch glass cover, having flame as high as possible without smoking. When nearly dry lower the light so that any iron that may have splashed up on watch glass may be redissolved and carried down into the dish. As soon as dry, remove watch glass and heat over lamp until all acid fumes are gone. Cool and add to pig iron 35 cc. strong HCl, and to steel 30 cc.; replace watch glass and place over low light until complete solution, then raise the light and evaporate as rapidly as possible with cover on, until solution is of very dark color, and about to stick. Remove from lamp, add 5 cc. strong HNO_3, shake about until well mixed and any that sticks may be dissolved, dilute with hot water to about 100 cc., washing off watch glass. Filter into 16 oz. flask, washing paper and residue with 2 per cent. HNO_3 and hot water. Add 25 cc. strong NH_4OH, shake up and then redissolve with 25 cc. of strong HNO_3 leaving solution but slightly acid. Heat to 85° and add 75 cc. ammonium molydate solution. Shake for 5 minutes. When well settled, filter through a 9 cm. Munktell filter, which has been dried at 110° for one hour and weigh between watch glasses. Wash well with 2 per cent. solution of HNO_3 and dry at 110° for one hour. Weigh between watch glasses. If arsenic or titanium be present, I follow Blair's acetate method after filtering from residue down to the basic acetate precipitate carrying phosphorus. This precipitate is dissolved in a dilute solution of HNO_3 and HCl in small beaker and warming. Filter from paper, remove HCl by evaporation, filter into 16 oz. flask and precipitate with ammonium molybdate solution.

If desirable and thought necessary dissolve yellow precipitate in dilute ammonia, by putting paper and all in beaker. Remove paper and silica and make magnesia precipitate.

MANGANESE IN IRON AND STEEL.

Color Method.—Weigh off 2 grams iron or steel, place in a 1×10 inch test tube, add 25 cc. HNO_3 of 1.2 Sp. gr. When solution is complete and all nitrous fumes gone, add about ½ gram PbO_2 and boil for 2 minutes, cool in water and when settled compare color with that of a standard which has been treated in just the same way. The manganese in the standard being determined gravimetrically. Dilute the standard to twice as many cc. as percentage of Mn and divide cc.'s of all compared with it by 2. It takes some time for solution of pig iron and the solution should be kept over a very low light so as not to concentrate bulk of solution until solution is complete before adding the PbO_2.

Gravimetric Method.—Dissolve 5 grams of steel in 60 cc. HNO_3 (1.2 Sp. gr.), evaporate to a pasty condition in a No. 4 beaker, then add 100 cc. conc. HNO_3, heat to boiling and precipitate MnO_2 with $KClO_3$, filter on asbestos and proceed as with MnO_2 in ores. Pig iron is treated in the same way as for phosphorus until filtering into 16 oz. flask. For Mn it is filtered into a No. 4 beaker and evaporated twice with conc. HNO_3 to pasty condition, then 100 cc. of conc. HNO_3 added and MnO_2 precipitated with $KClO_3$ and MnO_2 treated in same way as in case of steel or ores.

DETERMINATION OF CARBON BY COMBUSTION.

The steel or iron is dissolved in double chloride of potassium and copper which is dissolved in the proportion of 5 pounds to 6 litres of water, and has been filtered first through paper and then through asbestos. 5 per cent. of HCl is added to this solution as it is used. For 3 grams of steel use 180 cc. solution. If no stirring machine is at hand add solution to steel and stir frequently at first and let stand over night at temperature of room. Then warm on sand bath stirring frequently until all copper is in solution. Cool and filter through a boat lined with asbestos which has been burned and ground

up in water, decanting away the murky part leaving the fine asbestos, which by shaking up in a bottle with water can be easily transferred to boat to make the felt. The solution of steel is filtered on felt carefully washed with HCl, then warm water until free from HCl and Cu. The boat with carbon is dried at 80° or 90° for 1 hour, then burned with O in a platinum tube which contains a coil of platinum gauze and copper oxide.

The combustion train is made up as follows :

1st. Drying and purifying jars filled with KOH through which O passes to combustion tube ; following the combustion tube is a U tube filled on one side with anhydrous cuprous chloride and on the other with anhydrous copper sulphate, then a U tube filled with H_2SO_4 conc. to close lower part of the U. Following these are the absorption bulbs (Geissler's, potash with drying tube between the bulbs). The bulbs are filled with KOH of about 1.35 or 1.40 sp. gr.; the drying tube with $Ca\ Cl_2$. Connected with this is a Liebig bulb filled with H_2SO_4 to trap. Then comes a $Ca\ Cl_2$ tube used as a protection, but not weighed. Great care is used in always keeping the potash bulbs with the $Ca\ Cl_2$ tube filled with fresh material. A blank is always run before each day's series is begun, and this must agree with 1st weight to within .0005 gm. Where a number of combustions are to be made the Geissler and Liebig bulbs are weighed and then placed in train for next combustion, using weight from last one done until the series or day's work is done. Test joints each time the apparatus is put together. One of the essential requirements for good results is keeping the apparatus clean and being clean.

The tube is heated up by lighting burner nearest absorption bulbs and then, with oxygen flowing so bubbles go at rate of 3 per second, each burner slowly in succession, until the whole tube is red hot, using about ten minutes. Keep red hot for 15 minutes. Then cut off oxygen and apply suction with bubbles going at same rate; lower the lights for a few minutes,

then extinguish them. After suction has run for ½ hour the bulbs are ready to weigh.

DETERMINATION OF SILICON IN STEEL.

Five grams are dissolved in 50 cc. HNO_3 of 1.2 sp. gr., add 35 cc. dilute H_2SO_4 (1 part H_2SO_4 to 1 part water). Evaporate in 4½ inch dish over Argand burner with watch glass cover until bumping begins; remove cover and stir with rod until it grains or cakes. Dry until copious fumes escape. Cool, add about 20 cc. dilute HCl and 100 cc. water, heat until solution is complete, filter and wash well with HCl and hot water, burn and weigh.

Engineers' Society of Western Pennsylvania.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania was held in the Lecture Room of the Society, 410 Penn Ave., Pittsburg, Pa, Tuesday evening, October 20th, 1896, the president, W. G. Wilkins, in the chair.

The meeting was called to order at 8.30, 35 members and visitors being present.

The minutes of the last meeting were read and approved.

Reporting for the Board of Direction the Secretary read the names of two applicants for membership, the same having been approved by the board, and to be voted on at the next meeting.

Messrs. Frank T. Hogg, Thomas E. Hughes, Philip A. Lange, George L. Peck and Charles W. Ridinger were elected members of the Society.

The Secretary read a communication from Mr. Arthur Kirk in regard to an exhibit of paving brick, etc., at the Pittsburg Exposition, which communication was—upon motion—received and placed on file.

Mr. Kaufman then read the paper which he had prepared for the evening, entitled "Hydraulic Power Transmission."

HYDRAULIC POWER TRANSMISSION.

The number of Central Stations distributing through pipe lines or wires, water, light, power, heat and speech is, by our requirements and necessities, gradually on the increase.

It is the object of this paper to discourse, as briefly as possible, upon a system of power transmission from a central station which is largely in use in England. The success there attained has been so satisfactory, that it is surprising that no American city has as yet adopted the system. It is the distribution of water at very high pressure, from 700 to 2,000 pounds, per square inch. It depends upon the well known principle that water when confined in a vessel will transmit any pressure to which it is subjected equally in all directions, regardless of the shape or size of the vessel. If the vessel be a long pipe the pressure at each end will be the same. If any water is drawn from the pipe it is necessary to refill it immediately by means of pumps and accumulators.

The reputed originator of the system was Bramah, the inventor of the Hydraulic Press ; but to Lord Armstrong, the credit is no doubt due for the practical application of a system of pressure water for motive power purposes. From the first, he contemplated a distribution of pressure water in cities for the supply of motive power to many consumers. His great invention was the accumulator which is used for the purpose of maintaining a uniform pressure in the mains. Without this, the system would be impracticable on account of the great fluctuations in the demand for water by cranes and other intermittently working machinery for which this system appears to be entirely adapted.

Lord Armstrong was also the inventor of the hydraulic crane of a type used ever since. The pressure water acts on a piston, the motion of which is multiplied by reduplicating a chain over pulleys. He showed in 1840 that a continuously working steam engine of comparatively small size was capable of doing a large amount of distributed intermittent work, and

he urged that this would be more economical than the employment of a number of engines to drive each separate machine.

High pressure systems for distributing power to many consumers have been established in Hull, London, Liverpool, Birmingham, Manchester, Glasgow, Melbourne, Sydney and Antwerp. The first plant was established in Hull. The most important and best developed plant is that at London, operated by the London Hydraulic Power Company, organized in 1884.

The progress made in six years in the distribution of Hydraulic Power in London is shown by the following summary :

		Dec., 1887.	Dec., 1893.
1.	Miles of Mains laid.....	27	67
2.	Number of Pumping Stations.....	1	3
3.	Horse Power provided.....	800	2,600
4.	Power water supplied in 1 week...	2,474,400 U.S.Gals.	9,048,000 U.S.Gals.
5.	Number of Machines at work.....	609	1,925
6.	Capital Expended.....	$750,000 00	$2,105,000 00

PUMPING STATIONS.

In 1893 there were three pumping stations in the London plant:—the Falken Wharf Station, the Millbank Station, and the Wapping Station. A fourth pumping station was in progress of construction in 1894, but the writer has not been able to obtain any information concerning it.

The Falken Wharf Pumping Station may be described as a type of all. It is equipped with hydraulic pumps to draw water from the Thames and to lift it into storage tanks on the roof of the pump house. From the storage tanks, the water runs by gravity through filters in order to be cleared of all sediment, an essential operation for the protection of the valves of the system. After leaving the filters, the water is forced by the main pumps through the accumulators, into the mains at 750 pounds pressure per square inch. There are four sets of vertical compound Pumping Engines, each set being capable of exerting 200 indicated H. P. Each set of Engines will deliver 288 gallons per minute into the accumulators at 750

lbs. pressure at a piston speed of 200 feet per minute. The Engines are fitted with surface condensers; the condensing water being obtained from storage tanks over the engine house and returned to them by pumps. The quantity required for condensing is about the same as the quantity of power water delivered into the mains. The temperature of the water delivered into the mains is always between 60° and 85°.

In ordinary work about 3 lbs. of coal per H. P is used. During the trial of the Engines about 20 lbs. of steam per indicated H. P. were consumed.

The boilers are of the double-flued Lancashire type, with Galloway tubes and are made of steel. They are four in number, seven (7) feet in diameter and about 28 feet long.

The temperature of the feed water averages 76°, with steam at 82½ lbs. 3,744 U. S. gallons of water were evaporated with 3,460 lbs. of coal in 8 hours and 50 minutes.

The character of the equipment of the Pumping Stations at Millbank and Wapping is about the same as at Falken Wharf, the one at Wapping being larger than the other two.

There are six accumulators in use on the whole system and are located at different pumping stations. Four are 20 inches in diameter with 23 feet stroke, and two are 18 inches in diameter with 20 feet stroke. The total capacity of these accumulators is about 1,900 U. S. gallons. The pumping capacity of the plant is about 4,200 U. S. gallons per minute. These figures show that the accumulators act almost entirely as regulators of pressure and have a very small influence in respect to storage. The accumulators are loaded to give a pressure of 750 lbs. per square inch. Each accumulator is fitted with an electric bell which rings when the accumulators are half down as a signal to start an additional set of Engines if necessary to keep the supply up to the demand.

MAINS AND VALVES.

The power water is distributed through cast iron mains 6″ and 7″ in diameter. The velocity in the mains is about 3 feet

per second. At this velocity the loss of pressure is about 18 lbs. per square inch in a 6″ main per mile. This loss is insignificant on a high pressure system.

Prof. Unwin says, "that the losses of energy due to distribution in a hydraulic system, apart from those due to the pumping and motor machines, are so small in most cases, that they may be dismissed from consideration without any serious error."

In all the hydraulic systems, cast iron pipe with flanged joints, with two bolts, have been used. The mains are very tight and give good satisfaction. In two years but four breaks occurred.

The mains are laid in circuit and there are stop-valves about every 1,200 feet, so that any section can be isolated.

METERS.

The water power used by the consumers is invariably registered through meters attached to the waste pipes from the machines. From the meters the water passes to the sewers.

APPLICATION OF THE POWER.

The Hydraulic Power is used in London for elevators, cranes, presses, fire hydrants, pumps, and in a few cases for rotary engines. The main use at present is for running elevators. By means of intensifiers, by which the pressure may be readily increased to 4,500 lbs. per square inch, the pressure water is adapted to pressing purposes. Hydraulic Pumps are used by some consumers for pumping water from the chalk measures to tanks on the roofs of their houses.

One of the most interesting uses to which the pressure water has been put, is for fire hydrants. When, by means of Greathead's injector hydrant, a small jet of high-pressure water, is injected into the center of a larger jet from the city mains, the pressure in the latter is greatly increased and also the quantity. Thus, wherever the high pressure water mains are laid, there can also be a fire engine always ready for use. A hose was screwed to the mains where there was a pressure of

about 40 lbs. and the jet rose to a height of 40 or 50 feet. Water of 730 lbs. pressure was then turned on through a $\frac{3}{8}$-inch opening and immediately the stream rose to a height of 90 or 100 feet.

For continuously running rotary engines, hydraulic power is not economical. Considerable success has, however, been obtained with the Pelton Water Wheel in certain cases where it is only required to run at intervals, and for comparatively short periods during the day.

CHARGES.

The power water is sold to consumers at a certain amount for each 1,000 gallons. A graduated scale of charges is in use in London.

When 3,000 U. S. gallons or under are used per quarter, the rate is $1.66 per 1,000 gallons. When 300,000 U. S. gallons are used per quarter, the rate is 56½c per 1,000 U. S. gallons. For larger quantities the minimum rate is 30c per 1,000 U. S. gallons. Intermediate quantities are charged at corresponding rates.

The following calculations show how to determine the Horse Power delivered in any quantity of pressure water :

Let A = area of pipe in sq. ft.

Q = volume of water delivered per second in cu. ft.

Q^1 = " " " " " " gals.

p = pressure per sq. in.

v = velocity in feet per second.

Work done in 1 second = 144 A v p.

$$\text{H. P.} = \frac{144\ A\ v\ p}{550} = 0.262\ A\ v\ p = 0.262\ p\ Q = 0.035\ p\ Q^1$$

when p = 750 lbs. H. P. = 196.5 Q = 26.272 Q^1.

A 6″ main, 3 feet velocity, delivers .59 cu. ft. water per second, which is equivalent to 116 H. P.

From these formulæ we find that in 1,000 U. S. gallons,

delivered in 1 hour, there are 7.3 H. P. As 80% efficiency is claimed for hydraulic machines, this would be equivalent to 5.7 H. P.

1 H. P. per hour requires therefore $1,000 \div 5.7 = 175.4$ gals. To obtain 1 effective H. P. during 3,000 hours per annum at 80% efficiency—$175.4 \times 3,000 = 526,200$ gallons of water are required.

Hence a consumer taking 50,000 U. S. gallons per quarter would get the equivalent of 0.38 effective H. P. for 3,000 hours. This would cost him $202.00 or about $532.00 per effective H. P. per annum.

A consumer taking 300,000 U. S. gallons per quarter would get the equivalent of 2.28 effective H. P. for 3,000 hours. This would cost him $675.00, or about $296.00 per effective H. P. per annum.

These figures look very high, but are high in theory only; simply because the machinery for which the high pressure water is eminently adapted is only used intermittently and would not be used for 3,000 hours during the year.

The information which was given concerning the London plant was obtained from papers read before the Institution of Civil Engineers by Mr. E. B. Ellington, and from Prof. Unwin's work "On the Development and Transmission of Power," and it has been here reiterated for the purpose of bringing the subject matter of this paper clearly before the members of this Society.

The real purpose of this paper is to show that a plant distributing high pressure water would pay in Pittsburg, not merely through curiosity, but by this means to call the attention of the citizens of Pittsburg to the advantages of central power stations. They should be highly interested in all matters of this kind because the future welfare and progress of the city depends entirely upon the adoption of some system of power transmission. Effectual relief from the smoke nuisance can only be obtained in such manner.

In connection with Mr. S. Diescher, member of this Society, the writer has designed and estimated the cost of an imaginary plant suitable for the present requirements of the city.

The Pumping Station was given a location on the Allegheny river in the neighborhood of 20th street. There will be located the boilers, supply pumps, filters, storage tanks, main pumps, accumulators, etc., all arranged so as to permit of the most economical operation.

The plant was designed to give a supply of 600 gallons per minute, with sufficient extra pumping capacity so as to be provided for any emergency.

SUPPLY PUMPS.

Three Hydraulic Pumps, operated by the high pressure water from the mains, are proposed to draw the water from the river and lift it into storage tanks, the total lift being about 75 feet. If the site is favorable, the water could be drawn through infiltration galleries to clear it of all sediment; if this method is not practicable some mechanical filtering device can be used before admitting the water to the mains.

The storage tanks are two frost-proof tanks each holding about 100,000 gallons.

BOILERS.

There will be a battery of 8-100 H. P. boilers, which will be fitted with coal conveyors and stokers.

MAIN PUMPS.

There will be two sets of compound horizontal pumping engines the capacity of each set to be at normal speed, 600 gallons or 80 cu. ft. per minute, working against a pressure of 800 lbs. per sq. in. in the accumulators. The cylinders to be 25 inches and 48 inches in diameter; the plunger to be 9½ inches in diameter and the stroke to be 30 inches.

The plant could deliver about 400 H. P. continuously.

ACCUMULATORS.

There will be two accumulators, each 18 inches in diameter, with 21 feet stroke, loaded to give a pressure of 800 lbs. per sq. in.

MAINS.

The diameter of the mains was taken at 6 inches. As the capacity of a 6-inch main at 3 feet per second is 116 H. P., at least 4 mains are required to carry off the pressure water from the pump house.

Wrought iron flanged pipe tested to 2,500 lbs. per sq. in. to be used.

The mains were supposed to be laid on the principal streets down town, namely:—Liberty and Penn avenue from Twentieth to Fourth streets; Grant, Smithfield, Wood, Market and Ferry streets from Liberty to Water street; Water street from Smithfield to Ferry; First, Second, Third, Fourth, Fifth and Sixth avenues from Smithfield to Market.

The total length of the pipes in the above system of distribution is about 40,000 feet. About 13,000 feet of 2 inch pipe for connections and branches on streets and alleys not enumerated above were estimated for.

The estimated cost of a plant as above described is as follows:

PUMPING STATION.

3 Hydraulic Pumps and Foundations....	$ 4,000 00	
8 100-H. P. Boilers, set including Conveyors and Stokers.....	16,000 00	
2 Compound Pumping Engines.....	16,000 00	
1 Jet Condensor.....	2,000 00	
2 Accumulators.....	7,000 00	
Machinery Foundations.....	12,000 00	
Storage Tanks	6,000 00	
Buildings and Stack.....	10,000 00	
Property	27,000 00	$100,000 00

DISTRIBUTING SYSTEM.

40,000 feet of 6 inch pipe @ $ 1 00.....	$40,000 00	
2,000 pair flanges " 10 00.....	20,000 00	
13,000 feet of 2 inch pipe " 10.....	1,300 00	

7,000 pair flanges	"	5 00.....	3,500 00	
100 6-in. main st'l T's	"	30 00.....	3,000 00	
50 6-inch valves	"	54 00.....	2,700 00	
200 2-inch valves	"	8 00.....	1,600 00	
Laying pipe—53,000 feet	"	50.....	26,500 00	
200 meters	"	20 00.....	4,000 00	$102,600 00
Engineering and contingencies.....				27,400 00
		Total.....		$230,000 00

OPERATION.

The annual cost of operating this plant is as follows :

Interest on Plant—6 per cent. on cost.....	$13,800 00
Officers' and Office Expenses	10,000 00
Pumping Station, including fuel and oil.....	11,200 00
Distributing System.....	2,000 00
Repairs and Sundries	5,000 00
	$42,000 00

USERS OF HYDRAULIC POWER.

The machinery to which hydraulic power can be successfully applied in Pittsburg is practically the same as in London, namely :

1st. Hydraulic Elevators.
2d. Cranes.
3d. Hydraulic Intensifiers.
4th. Fire Hydrants.
5th. Hydraulic Engines.

HYDRAULIC ELEVATORS.

Hydraulic Elevators are now recognized to be in all respects superior to all others. They last for years without any repairs or attention accept requiring new packing at long intervals. The Hydraulic Elevators which are in use in Pittsburg, are run either by direct City pressure or by the pressure obtained by pumping water from the City mains into tanks on the roofs and using the water over and over again. The latter is called the Pump-over System.

By furnishing water for running elevators, the City has been running a Hydraulic Power Transmission System. The following table shows the number of direct pressure elevators, amount of water used, and the rates collected by the City:

DIRECT PRESSURE ELEVATORS IN PITTSBURG.

Number of Elevators.	Rate charged Per 1,000 Gals.	No. of 1,000 Gals. used.	Amount Assessed.
14	Below 10c	135,426	$10,783 00
4	Bet. 10c and 12c	15,750	1,680 00
9	" 12c " 14c	31,010	4,070 00
12	" 14c " 16c	27,942	4,281 00
15	" 16c " 18c	24,972	4,325 00
26	" 18c " 20c	23,713	4,632 00
22	Above 20c	23,085	5,656 00
102		281,888	$35,430 00

These elevators are with three exceptions located in the 1st, 2d, 3d, 4th and 9th wards, and are easily accessible to the distributing system above given.

Assuming a pressure of 70 lbs. per sq. in. the H. P. in 1 cu. ft. per second is $0.262 \times 70 = 18.34$.

H. P. in 1 U. S. Gal. $= 18.34 \div 7.48 = 2.452$.

" 1,000 U. S. Gals. $= 2452$.

" 1,000 U. S. Gals. per hour $= 0.68$.

Effect. H. P. in 1,000 U. S. gallons per hour $= 0.544$ @ 80% efficiency. 281,888,000 Gals. per year, for 3,000 hours is equivalent to 94,000 gals. per hour. Therefore the average H. P. furnished by the City for direct elevator service equals $94 \times 0.544 = 51$, a rather small amount.

For this the City received $35,430, which is at the rate of about $700.00 per H. P. per annum.

From the records of the Water Bureau it is possible to find out the amount of City water used annually by any direct pressure elevator and the amount paid to the City. The writer has made a number of calculations to determine whether it be cheaper for such consumers to use high pressure water based upon the rate charged by the London Hydraulic Co.

One elevator paying $450.00 annually would have to pay $297.00 for high pressure water. One paying $760.00 could get power for $534.00. Still another paying the city $850.00 could get power for the same service for $639.00. Invariably

such calculations have shown that the high pressure water is more economical than the low pressure water furnished by the city.

From a few inquiries made by the writer, it would appear that those persons who use electric elevators, have to pay more than those having direct pressure elevators.

If all the direct pressure elevators were supplied with high pressure water, a company furnishing such water would derive a revenue of about $22,000.00 annually.

As many persons using electric, steam and hand power elevators would adopt the hydraulic power elevators upon the first opportunity given them, it is reasonable to assume that the total from elevator service alone would be at least $30,000.00 annually; thus, easily, paying all running expenses exclusive of interest on the investment.

HYDRAULIC CRANES.

A limited number of cranes and winches could be placed in the district piped. The railroads and certain manufacturers would probably be the customers who could use them to advantage.

FIRE HYDRANTS.

In the writer's opinion, great benefit can be given to business and property holders in general by increasing the fire protection in the lower wards of the city. From forty to fifty million dollars' worth of fire insurance is constantly placed with the various companies for this section of the city and if the risks were less the rates would be correspondingly lower.

One of the most serious objections to the modern skyscraper would also be done away with.

The value of the injector fire hydrant as an auxiliary to the city fire department can only now be a matter of conjecture; but it would seem that at least from $12,000.00 to $15,000.00 could be annually secured from such a source by a company furnishing pressure water.

From the above estimates it would appear that there is enough business in sight to justify the construction of a Hydraulic Power system in Pittsburg, and with that conclusion, the writer is content that he has proven, that the establishment of an Hydraulic Power plant would be an excellent investment for capitalists and a step towards making life worth living in Pittsburg.

It will be noticed that in the estimates of receipts above given, no revenue was counted upon from pump-over elevators, pressure plants in mills, or rotary engines. This was done for the reason that all estimates of receipts from these sources must be guesses.

Calculations show that there is no economy in the use of high pressure water for pump-over elevators or rotary engines. But there are many cases where considerations of ease, safety, cleanliness and convenience will overbalance those of economy. There are many rotary machines which are run but a few hours during the day and which, if run by Pelton Water Wheels, would give the owners more satisfaction than if run by any other motor. Such machines may be found in printing establishments, ice cream manufactories, small machine shops and so forth. Judging from the experience in London there would be a large revenue from such users.

Divers industries, whose existence would be made possible by having at command reliable and economical power, would spring up from time to time, so that it would seem the Hydraulic Power plant could be made to be exceedingly lucrative.

It does not seem probable that high pressure water, delivered from a Central Station, could be advantageously utilized to do all the power work required in a modern office or store building. There are, however, many cases where it could be used economically for running the elevators, and gas gas engines utilized for generating the electric light. The use

of anthracite coal or even natural gas for heating purposes, would not in many cases, bring the total cost up to the present cost.

Such an arrangement is a simple and efficacious method of doing away with a great deal of the smoke now polluting the atmosphere of Pittsburg. The writer does not care to state that it is the best method of accomplishing the abatement of the smoke nuisance; he is, however, convinced that engineers can readily, if they are specifically employed and directed so to do, clear Pittsburg of its bane without hardship to anyone. All that is required, is for the authorities to pass and enforce rigid laws, and the engineers will do the rest.

The President. Two points in Mr. Kaufman's paper impress me, and I have no doubt many of those present. The first is the comparatively low cost of the plant, and second, the high cost of hydraulic power as now supplied by the city water works. Discussion of this paper is now in order.

Mr. Emil Swensson then presented some remarks on Mr. Kaufman's paper, prepared by Mr. Geo. S. Davison.

DISCUSSION.

Hydraulic Power Transmission.

Geo. S. Davison. It might have been well in the paper read to have anticipated and answered the question: Could air be used as the medium of transmission of power instead of water?

This medium would possess the advantages that the site of the pumping plant would not of necessity be confined to a point in close proximity to a body of water; that after extracting the energy of which it was temporarily possessed, it would require no sewer system to carry it out of the way; that there would be a large saving of power at the pumps by reason of the reduction of friction of the air in the pipe system and that

there would not be as much difference in the pressure furnished two consumers at different elevations, as there would be in the case where water was used as a medium.

However, we would likely be told that it would be highly impracticable to use air owing to its compressibility. It would be impossible to change its pressure from one atmosphere to that of 54 atmospheres (800 pounds) except through a number of successive pumpings and cooling processes that would prove to be a cumbersome scheme. The reason for raising the pressure by stages, can be understood if one were to imagine an air compressing pump that might be required to produce a pressure of 800 pounds. At the commencement of the first stroke the pressure that the piston would be working against would be one atmosphere, say 15 pounds. It would slightly compress the first cylinder full and shove it by the valves into the receiver, by the aid of that slight increase in pressure. As the receiver would receive each charge of air the pressure at the end of each stroke would increase but would always remain 15 pounds at the beginning of the stroke. Imagine the diagram of the power required for a stroke of the pump when the pressure in the receiver would reach 800 pounds. There would be 15 pounds pressure to overcome at the beginning of the stroke, which pressure would be increased immensely as the volume of air in front of the air compressing piston decreased, until the said piston reached a point where the clearance ahead of it would be less than 1-54 of the contents of the air cylinder. Then, if the valve to the receiver was forced, there would be an infinitesimal volume of the medium stored, accompanied by intense heat.

It might have been interesting for the author of the paper to have described the accumulators used. We would suppose that they are vertical cylinders that telescope with a vertical chamber on the discharge pipe from the pumps, and are so weighted to give the necessary pressure at the pump end of the system, in this case 800 pounds per square inch; and that

this telescoping cylinder rises and falls as the demand on the system temporarily is less or greater than the supply from the pumps.

We note that the accumulators for the plant proposed by the author are about the size of those used in London. Each would contain but one-half minute's supply for the system, an amount that would seem to be dangerously small, as there would be a great fluctuation in the actual amount of water required. In the London plant it is explained that an electric bell indicates when the accumulator is half way down, as a signal to start additional pumping engines. In ordinary practice it would seem that the accumulator would be bobbing up and down so rapidly, that an automatic regulator, controlling the speed of the pumps, would be a better plan. In either case it would seem that a steam pumping plant supplying the pressure for such varying quantities of water, could not be expected to make an economical showing.

A pressure of 800 pounds per square inch for the accumulator suggested in the paper would require a counterweight of 203,600 pounds; quite an item. This counterweight would probably be iron, as even of a substance of such great specific gravity, it would require more than 400 cubic feet. There should be some special device to overcome the friction between the parts of the accumulator, as it would seem that a packing ring sufficient to withstand such a high pressure would have a large retarding influence on the movement of the top portion of the accumulator.

In making an estimate on the cost of the proposed plant, the costs of the items mentioned have been very liberally treated, which would seem to argue that there would be even more left for contingencies and the engineer than figured upon. Such a result would be highly gratifying to the engineer, provided contingency would be reasonable.

If I may be permitted, I would suggest a change in the pipe system. It would be to use two 8-inch mains from the

pumping plant to the business part of the city instead of four lines of 6-inch. They would certainly be cheaper, and would possess the advantage of delivering the same quantity of water, with a great saving in friction head. I note that the pressure at the accumulator is to be 800 pounds, and at the point of delivery 750 pounds. One mile of the 6-inch lines would cause a loss by friction of about 65 pounds per mile; the 8-inch lines but 25 pounds, as it would be more than one mile to the point where the branch lines would diverge, the 8-inch lines must be used to keep within the limit of 50 pounds loss as estimated for the entire system. Then again, 4-inch lines could be used on First, Second, Third, Fourth, Fifth and Sixth Avenues, thus effecting a saving in cost. These smaller pipe would be ample, as the clear water to be supplied would not clog them, as in the case with water carrying a large amount of sediment.

The pipe on the above avenues should be extended to Grant street, and in some cases to Ferry street. The 8-inch lines on Penn and Liberty avenues should be connected frequently, such as at Fifteenth, Eleventh, Ninth and Sixth streets, so that like any other part of the system, portions of these mains could be cut out temporarily while connections were being made.

Mr. Kaufman—I called attention in my paper to the small capacity of the accumulators in London as compared to the consumption of the whole system; but experience there indicates that there is not that "bobbing up and down" of the accumulators spoken of by Mr. Davison. There are so many machines working there all the time that the draught is approximately regular; there is a large variation in the draught during the course of the day, the draught during the middle of the day being the largest. The increase and decrease in the demand is gradual.

I think the point made by Mr. Davison about using an 8-in. line a very good one. I did not attempt to make a very accurate design; merely desiring to get the cost of a plant approximately.

Mr. T. P. Roberts—I have listened to the reading of Mr. Kaufman's paper with a great deal of interest; in fact I had the pleasure of reading a copy of it before I came here to the meeting, and I will just caution the speakers in regard to the matter of increasing the diameter of the pipes under this exceedingly heavy pressure.

I think—without having made any calculations—I would favor a pipe of smaller size on the score of safety.

Thinking I might not be present this evening I prepared a few remarks on this paper which I will now read:

Mr. Kaufman, I think, deserves much credit for having brought to the attention of the Society and to the public of Pittsburg a method for the use of a power in our cities which has important advantages not possessed by either steam or electricity. Of course the most important advantage to result to the general public by the introduction of high water pressure mains in our streets would be manifested in the abatement of much of the smoke which blackens and disfigures papers and goods of all kinds in Pittsburg. It is a mistake to suppose that it is smoke from the great mills which does this damage; the mills of Pittsburg are in groups distant from the business section, and while the sky may be darkened over the entire area of the city, from "their smoky banners in the sky," the radius of the deposition of soot in appreciable quantities is restricted to a distance of a few blocks from any particular smoke stack. With all that has been done with smoke consumers at the numerous store and office buildings, where they have been introduced, we find at numerous points smoke curling from chimneys directly into the open windows of adjacent buildings.

Mr Kaufman's analysis of the operations of Hydraulic transmission of power in the city of London relieves his hearers from considering his proposed application of the same system to Pittsburg as the enunciation of a novel theory. His paper may be considered in reality a *prospectus* of a business scheme worthy of the serious attention of capitalists, and of

the city legislators. It is not likely, however, that the city itself would ever undertake to go into the business of furnishing hydraulic power to its citizens, but in view of the fact that the system proposed by Mr. Kaufman, would greatly improve the means for combatting fire, especially in tall buildings, the authorities would be well warranted in making liberal concessions to the company which might be organized to do the work, hence if ever undertaken it should be under the auspices of a quasi public corporation.

Because we may have no American precedent for adopting systems which have proved successful abroad is no reason for the belief that such systems possess no merit. A number of industries, no doubt, could be profitably established in Pittsburg, now unknown to us; if their merits were inquired into by home capitalists possessed of the ability to regard things with an unprejudiced eye. The first American street railway tracks laid in England were torn up by an excited mob, and similar prejudices have existed in the past in this country against the adoption of foreign methods of doing things. Such childish ideas happily no longer prevail, but there does yet remain a lamentable ignorance in many directions regarding good things which might be introduced among us from abroad.

Messrs. Kaufman's and Diescher's calculations of cost and performance of their imaginary high water pressure plant for Pittsburg, from the well-known abilities of the gentlemen, may be accepted as correct for the purpose intended by them, viz.: introducing this subject to the public attention. There is certainly no appearance of an underestimate when they place an effective horse power per annum at $532.00.

I understand this to be the cost for 3,000 hours of continuous service—that is to say 10 hours' continuous service for 300 days in the year. This, as was remarked by Mr. Kaufman, appears very high, and it certainly is too high a cost for certain applications of power. But as it is not contemplated by the author of the paper to do a general power furnishing

business, but for the main part to supply power to elevators, cranes, presses, pumps, fire hydrants and other service where it is used intermittently and as such service can be accurately metered; its cost per annum in some cases per horse power might be less than can now be obtained either from direct steam or electric power. Whether with the use of "intensifiers" elevator service per hour of horse power can be reduced from the figures of the paper would be an important consideration in the cases where elevators run at minute or very frequent intervals. Still in the case even of minute elevator service the running time of the machinery does not average more than one-half the actual working day.

I am inclined to think that a careful canvass of the business district of Pittsburg would reveal more instances where the high water pressure could be advantageously applied than may be inferred from Mr. Kaufman's paper. Hydraulic power is more certain in its action than any other, besides, by avoiding the use of fires, it requires very much less attention than would steam power. Moreover, there is so little of a hydraulic working plant subject to wear, that cost for renewals of parts would be reduced to the minimum. These are among the advantages of its use. Of the disadvantages of hydraulic power, I know of but one, viz.: Inability to make it do all the work which steam engines are called upon to perform in our great cities.

While the paper occasionally offers opportunities for suggestions and possibly the criticisms of hydraulic experts in matters of detail, I look upon it as something out of the the usual order in our Society—a paper where authors may well say, "hang the details: Is the general idea a good thing and worth considering?" Where in the world can the city of London on 67 miles of high pressure mains find employment for 1,925 hydraulic machines?—that is about 29 to the mile. Smoke and dirt is as cheap in Pittsburg as it is in London to-day, and with street mileage compared in the business district,

Pittsburg ought to show up equally well with London. Yet not more than about 15 hydraulic machines per mile, are figured by Messrs. Kaufman and Diescher as compared with London's 29 machines per mile. As a Pittsburger, I feel that this discrimination is unpatriotic. We should, at least I hope, equal London's rate, and even perchance, add one more twinge to the sleepy old lion's tail.

Prof. Fessenden—On the question of elevator service I would like to compare a few figures. If we take Mr. Kaufman's figures, we get for the cost of one-horse power per year, hydraulic power, five to seven hundred dollars. The great disadvantage in the case of hydraulic power is that it is not economical at light loads, that is to say, in any case of the systems with which I am acquainted. If you have an elevator not fully loaded you have to use as much water and therefore power as when it is full.

A one-horse power electric motor tank and pump we may estimate at, say $1,200. This is not an exact figure but we will assume it as somewhere near correct. In this city of Pittsburg the power costs about 10 cents per horse power per hour. Therefore one horse power for a year would cost $300. Add to this $120 for interest on the plant and we get $420 as against $600 for the hydraulic power; therefore, there would not seem to be much opening for hydraulic power in competition with this method.

Mr. Kaufman—I have made about four different inquiries on that point. I did not attempt to go into exact calculations. I selected a number of establishments in the city having about the same sort of service, and found that electric elevators cost at least 50% more than the direct pressure elevators.

Prof. Fessenden—I was not speaking of elevators driven by electric motors, which is probably the most inefficient way in which continuous current motors can be used, but was speaking particularly of elevators where water is

pumped by electric motors, the "pump over system." I cannot see where direct hydraulic power would come in at the figures given by Mr. Kaufman.

Mr. Lewis—I would like to ask one question in relation to hydraulic pressure in elevators. With a light lift there is just as much water used as with a lift of the full capacity. Now, my education has been along the line that work cannot disappear, and in case of lifting a light load where does the excess of the work go; what absorbs it? The foot pounds consumed in lifting depend on the height lifted and the number of pounds weight, and if you lift only 2,000 pounds in one case and 4,000 pounds in the other, and consume an equal amount of water, what has become of the power which has not been utilized?

Prof. Fessenden—Supposing you have, for instance, 4000 pounds pressure, you have 3399 pounds to lift against; then the load will rise very slowly. Supposing then you take only 2000 pounds, now the load instead of rising slowly will rise quickly and when you get to the top it would have a certain velocity which shows where the extra work is.

It does not necessarily follow that the actual travel of the elevator must be faster; it may be or it may not be, but if it is not faster you must check the speed in some way so as to absorb the extra power.

Mr. Lewis—I have a theory to the effect that the pressure—actual working pressure—in an elevator cylinder varies, even if the speed does not vary. In driving an elevator it is run at about equal speed at all times, and my idea is that the pressure in the cylinder varies with the load, this difference being obtained by throttling.

Prof. Stewart—If the speed of the elevator is to be constant, it means that the pressure on the plunger must be less for light than for heavy loads. When running under less than the maximum load for which the elevator was designed, the pressure on the line must be throttled.

Now in throttling that pressure in the ordinary way you have a stream of water at high velocity issuing into a body of water at lower velocity and as a result eddy currents would be formed. The mechanical energy disappearing in this case is transformed into heat.

A cubic foot of water, at say 40 lbs. per sq. in., represents 5760 foot lbs. of work. If throttled to say 10 lbs., it represents but 1440 foot lbs. The act of throttling from 40 lbs. to 10 lbs. per sq. in. causes the equivalent of 4320 foot lbs. of work to appear as heat. This would amount to about 5.5 B. T. U. per cu. ft. of water, and would elevate its temperature by about 0.09 degrees Fah.

Mr. Bole—I was surprised to learn from Mr. Kaufman's paper that they have 800 pounds pressure with only two bolts in the flanges.

The President—They must have been pretty good sized bolts. I would like to ask if there is any wrought iron pipe made here which would stand that pressure?

Mr. Kaufman—The bolts used are about 1½ in. diameter, and are strained to about 8000 lbs. per sq. in. Wrought iron pipe suitable for hydraulic work is made here.

Adjourned.

Daniel Carhart,
Secretary.

MONTHLY MEETING OF CHEMICAL SECTION.

The regular monthly meeting of the Chemical Section of the Engineers' Society of Western Pennsylvania was held in the lecture room of the Society, 410 Penn Ave., Pittsburg, Thursday evening, October 22, 1896, President J. M. Camp in the chair.

The meeting was called to order at 8:30. There were 14 members and two visitors present.

The minutes of last meeting were read and approved.

Dr. Phillips, for the Committee on Methods, reported that but two more papers remained for publication. The question of having a brief summary of the methods made by the committee at the close of the series was discussed by the Society, but no action was taken at this meeting.

Dr. Phillips then gave a very interesting account of the work done at the Buffalo meeting of the American Chemical Section of the American Association for the Advancement of Science.

Mr. Linton read the paper of the evening entitled, "The Manufacture of Oxygen."

THE MANUFACTURE OF OXYGEN.

The chemical process of oxydation plays such an important part in manufacturing industries, and combined with the physical phenomena which it produces, especially light and heat, is such a universal factor in all industry, that it has doubtless occurred to very many who are engaged in manufacturing, to question why more attention has not been given to the cheap manufacture of pure oxygen on a large scale, and its use in place of mixtures and compounds containing it which at present furnish it for oxydizing processes. Especially so when one considers the vast supply of raw

material at hand, since a fifth of the atmosphere, a third of the water and a considerable portion of the earth are composed of oxygen. True, when one begins to think out processes for obtaining it cheaply and applying it safely and economically, numerous difficulties are met with, apparently too numerous to make it profitable to carry on a series of costly and tedious experiments to attain an end which might after all afford little or no improvement over present methods. The problem has, however, occupied much of the attention of chemists at one time and another and many processes have been proposed, some even patented, but they have never led to the manufacture of oxygen on a large scale until recently.

The most familiar methods of preparing oxygen gas are the following:

1. By heating oxide of mercury:

$$HgO = Hg + O.$$

2. By heating chlorate of potash:

$$2KClO_3 = 2KCl + 3O_2.$$

3. By heating a mixture of bichromate of potash and sulphuric acid:

$$K_2Cr_2O_7 + 5H_2SO_4 = Cr_2(SO_4)_3 + HK\,SO_4 + 3O.$$

4. By heating superoxide of manganese:

$$3MnO_2 = Mn_3O_4 + O_2.$$

5. By adding oxide of cobalt to a solution of hypochlorite of lime:

$$Ca(ClO)_2 + 2Co_2O_3 = CaCl_2 + 2O_2 + 4CoO.$$

6. By pouring water on a mixture of 1 part superoxide of barium and 2½ parts ferricyanide of potash:

$$Ba\,O_2 + Fe_2\,(CN)_6\,(KCN)_6 = 1Fe(CN)_2K_3(CN_4)_2Ba + O_2.$$

All these methods follow the idea of dissociating the oxygen from some oxide—they are of course very expensive and furnish but small quantities of the gas, for the quantity of raw material is in each case limited. On this account the attention of experimenters along this line was directed to the atmosphere, which contains an inexhaustible supply of oxygen and in which

the oxygen is not chemically combined, but merely mixed with the nitrogen, although mixed so thoroughly and uniformly that the proportions are practically unvarying and the two gases are about as hard to separate as if they were actually combined. The attempt has been made to utilize the fact that oxygen is more soluble in water than nitrogen. And by repeated dissolving of air in water and expelling it again, it does become decidedly richer in oxygen. Also use has been made of the fact that nitrogen passes more readily through a porous wall when under pressure than oxygen does, and by applying a high pressure to air in a receiver made of some porous stone the percentage of oxygen in the air was somewhat raised. But by neither of these processes can pure oxygen be obtained from the atmosphere, and no process for its manufacture was ever attended with any success until about half a century ago when Boussingault, an eminent French chemist, patented the following process: The element barium forms two oxides, BaO and BaO_2. Barium superoxide BaO_2 is formed when BaO is heated in the air to a temperature of 500° centigrade or more up to 800° centigrade. At the latter temperature it dissociates however and is resolved back again into oxide of barium and free oxygen. That is:

At 500°—$BaO+O=BaO_2$.

At 800°—$BaO_2=BaO+O$.

The process was apparently very simple and by the use of suitable apparatus Boussingault did succeed in carrying it out. But his success was only partial, for it was soon remarked that the quantity of oxygen furnished grew ever smaller and smaller until finally none at all was given off. It seems that no practical effort was made to get at the real cause of this, but Boussingault being discouraged at the first failure gave up his attempts, and satisfied himself with the explanaation that after being in use for some time the oxide of barium became inactive. The process was therefore dropped until a few years ago when Brin Bros., two English chemists, took it

up and going about the solution of the problem in a practical way soon made it clear why the oxide of barium became inactive. Although the atmosphere is chiefly a mixture of oxygen and nitrogen, yet there are always minute quantities present of carbonic acid, moisture and dust, and these are all very detrimental to the success of the operation. For,

1. $BaO+CO_2=BaCO_3$.
2. $BaO+HO_2=Ba(OH)_2$.

and dust which is chiefly combustible burns to carbonic acid and then combines to form carbonate of baryta. The carbonate and hydrate are compounds that do not decompose at 800° and therefore when once formed they take away a portion of the total oxygen producing oxide of barium and in the course of time nothing is left but these two salts, the consequence being of course that no oxygen can be extracted with them from the air. Brin Bros. took out a patent on the process, consisting chiefly in purifying the air before it comes in contact with the oxide of barium. Thus modified the process has been in successful operation for several years. Further improvements mostly mechanical have been made by Dr. Elkan, who operates a plant at Berlin, Germany. The arrangement and equipment of Dr. Elkan's plant is very advantageous and complete, and it may be taken as a model plant operating the Brin process. It consists in first a furnace fired with gas and carefully kept at a temperature of 800°. In this are hung long iron retorts shaped much like test tubes. Into each retort a pipe extends reaching nearly to the bottom and around this pipe the retort is filled with coarse granular oxide of barium nearly to the top. The air is forced through the pipe and the oxygen is absorbed as it passes upward through the oxide of barium. The rest of the plant consists in a pump to force the air in, draw the oxygen out and pump it into a gasometer. It was stated that the furnace is kept at a constant temperature of 800°. Formerly the temperature was varied when the pump was reversed but this has been found to be unnecessary as the air is

pumped into the retorts cold and this in itself serves to cool the oxide of barium in the retorts down to a sufficiently low temperature to admit the formation of superoxide. The pump forces air into the retorts for a certain time, then reverses and draws out the gas. At first the gas which comes out is impure, being mixed with nitrogen which remains in the retort when the pump reverses. This must be allowed to escape and only when pure oxygen begins to flow from the retorts is it pumped into the gasometer. The pump works automatically, reversing, pumping the pure oxygen into the gasometer and the impure into the waste pipe with fine precision. The producer which supplies the fuel gas for firing the furnace is built below and in front of it. The air is passed through several scrubbers filled with caustic soda which absorb the moisture and carbonic acid and since the moisture makes the surface of the lumps of soda moist and sticky, the dust also adheres to them. The caustic soda must of course be renewed from time to time and the scrubbers are so arranged that the air passes first over caustic soda that has been in use longest and last over the freshest. In using purified air the oxide of barim never becomes inactive but remains in continual use as long as the factory operates. Only one man is required to operate the plant.

With the oxygen in the gasometer we are not yet through with it for it must be delivered to the consumer. Its use is not general enough to make it practical to deliver it through a pipeage system. It is therefore compressed to 1-100 of its volume and transported in steel receivers. Great care is necessary in compressing the oxygen as the energy of compression is transformed into heat sufficient to burn a compressor up, since most of the metals burn in oxygen. The compressor is a double machine made of bronze and operated under water, the water serving to lubricate and cool it. The gas is compressed in the first compressor to 1-10 of its volume, passes then into the second where it is again compressed to 1-10 or 1-100 of its original volume and filled into the receiver. A pressure

gauge shows when the desired pressure is reached. The receivers are furnished with reducers which reduce the pressure from 100 atmospheres to one but little above the normal, merely sufficient to give an evenly flowing stream of oxygen. The receivers used in Germany stand a pressure of 350 atmospheres, and all are required to stand a test pressure of 250 atmospheres before being used, 2½ times the pressure to which they are subjected in actual use.

Oxygen gas thus manufactured has come to be used quite generally in laboratories, in certain lines of chemical manufacture, for calcium lights and other forms of the oxyhydrogen blow-pipe, and in addition to processes which require the use of oxygen, the cheap manufacture of it has stimulated the development of new processes in which it is used. As an illustration of this and of the possibilities in this direction reference might be made to the "Thomas Process" for the use of oxygen in glass manufacture, a process as yet however only in the experimental stage. In following it, after the glass is melted down somewhat, so that it has become a thick doughy mass, and the melt is about one-third made, a platinum tube is introduced into the pot or tank and oxygen passed through it into and through the melting glass for about twenty minutes. It is claimed that in doing this the length of time it takes the glass to melt is very greatly reduced, in some cases even cut down one-half. The oxygen also serves to make the glass a lighter color, as it oxydizes nearly all of the iron present to the ferric oxide which imparts only a feeble yellow color to the glass while if it remained in the form of ferrous oxide it would color the glass green in a much more intense degree.

A new process for making oxygen has been recently brought out by Prof. E. B. Stuart, of Chicago, and put in operation at the works of the General Gas Co., at East Chicago, Ind., in which use is made of an alkaline manganate to extract oxygen from the atmosphere. Through the kindness of Prof. Stuart I am enabled to give a description of the process.

A mixture of caustic soda and black oxide of manganese is heated to a temperature of 500 or 600 deg. Fahrenheit and air is then blown through it. The oxygen is absorbed with the formation of manganate of soda and the nitrogen passes off, the reaction being as follows:

$$2\ Na\ OH + Mn\ O_2 + O = Na_2\ Mn\ O_4 + H_2O$$

After ten minutes of the air blast it is stopped and a blast of steam passed through, which effects the dissociation of the manganate and liberation of oxygen, this reaction being as follows:

$$Na_2\ Mn\ O_4 + H_2O = 2\ Na\ OH + MnO_2 + O$$

The idea is not altogether new, though heretofore the process has not been successfully operated. Tessie du Motay in 1866, patented a process in which he used an alkaline manganate in intimate mixture with a slight excess of alkali, which in granular form was introduced into retorts and exposed alternately to the action of steam and air. The steam, however, acted to dissolve the mixture and melted it down to a viscid mass through which steam and air could no longer be forced. Other experimenters tried to prepare alkaline manganates which should be sufficiently insoluble to withstand the action of the steam, and among various suggestions along this line, we find the use of such insoluble substances as pumice, kaolin, etc., and coating the granules with cupric oxide or oxide of manganese. Fanta, who was associated with du Motay, at one time increased the proportion of free alkali to ten or fifteen per cent., and kept the mixture for some time at a very high temperature. The mixture prepared in this manner withstands the action of steam remarkably well, but eventually the steam attacks it as well, the granules coalesce and melt down. When Prof. Stuart first took up the process, he also tried to prepare a manganate which should be insoluble and made double manganates containing oxides of alkaline earths, e. g. $Ca\ Na_2\ Mn_2\ O_3$. While working on this it occurred to him to use a

fusible manganate which should be liquid at the temperature of the reaction. After some experiments he found that a mixture of one part of manganate of soda with two of caustic soda answered the purpose satisfactorily. This is the principle of the process which has been put into operation at East Chicago. The apparatus consists of cast iron retorts placed vertically and provided with three-inch pipes for air and half-inch pipes for steam. Each of these reaches to the bottom of the retort, where from a header, five leaders distribute the flow, that of the steam through one-sixteenth holes and of the air through quarter-inch holes. The retort is charged with 1,500 pounds of the mixture, containing 500 pounds of manganate of soda. The air blast is turned on for ten minutes and the steam blast for five minutes alternately. Two retorts produce 76,000 cubic feet of oxygen in twenty-four hours at a cost of between six and seven cents per 1,000. The cost is given in detail as follows:

One ton coal	$1 40
Two men	3 00
Cost of steam	50
Total	$4 90

However, the cost could be much reduced in a manufacturing establishment where waste heat could be utilized and the engineer combine the care of other machinery. Also it would take no more labor and but little more fuel to operate six or more retorts in one furnace than two, as at the General Gas Co.'s plant. So that the cost in the case cited may be fairly taken as a high estimate.

The use made of oxygen at this plant is to employ it in place of air for making fuel gas. A mixture of oxygen and steam is blown into the producer, and this gives a gas rich as water gas without the waste of fuel and time which the water gas process entails, by the alternate hot and cold blowing. The process is a new departure in gas making and the experi-

ments of Prof. Stuart and the General Gas Co. in developing it will be watched with much interest. Prof. Stuart states that they produce 70,000 cubic feet of gas from a ton of coal, containing 6% of ash, by this process.

DISCUSSION.

This paper was discussed by Messrs. Camp, Purves, Koch, Phillips and others.

THE PRESIDENT—You have listened to Mr. Linton's excellent paper and no doubt he is willing to answer any questions which the members may ask.

JAMES PURVES—Has Prof. Stuart gotten over the difficulty which he at one time found that the mixture must be partially renewed from time to time?

MR. LINTON—I am acquainted with this process only by correspondence with Prof. Stuart, but in his estimates of cost he makes no allowance for renewal of the raw material.

THE PRESIDENT—In the Brin process how is the point determined at which fine oxygen begins to flow from the retorts?

MR. LINTON—I believe that is merely a question of time, it being ascertained by experiment how long it is necessary to allow the gas to escape into the air.

PROF. PHILLIPS—At what price can oxygen be placed on the market?

MR. LINTON—The General Gas Co. do not market it, but use it for making fuel gas. You know fuel gas at present is made according to two general processes—the continuous process, where air and steam together are forced through a bed of coals, forming a gas composed chiefly of carbonic oxide, hydrogen and nitrogen; and the intermittent process, in which air and steam are blown through alternately, and the gas formed by the current of steam passing over the incandescent coals utilized only, this gas, "water gas," being composed of

hydrogen and carbonic oxide and therefore all combustible. By using oxygen instead of air in the continuous process we obtain a gas having the thermal value of water gas, without the waste of fuel and time involved at present in the water gas process.

Mr. Purves—If oxygen can be produced cheaply there will be a large demand for it for use in producers. The use of oxygen alone leads to a greater heat in the producer and hence greater dissociation. It must be remembered that a large portion of the oxygen in the producer gas is obtained from the steam. Do Brin Bros. claim that with purified air no renewal of the barium oxide is necessary?

Mr. Linton—Yes.

Mr. Purves—I had understood that even with purified air the barium oxide in time became inert.

Dr. F. C. Phillips—Some time ago the following process went the rounds of the German Chemical Journals: Heat lead oxide with lime in air to form plumbate of lime. Decompose by means of steam, giving free oxygen; then heat in air again to form plumbate of lime which can be decomposed again with steam The method works satisfactorily except that owing to the high combining weight of lead the yield of oxygen is small.

The meeting adjourned at 10 P. M.

A. G. McKenna,
Secretary.

Engineers' Society of Western Pennsylvania.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

November 17, 1896.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania, was held in the lecture room of the Society, No. 410 Penn Avenue, Pittsburg, Pa., Tuesday evening, November 17, 1896, Emil Swensson, Vice President, in the chair. The meeting was called to order at 8:27, fifty members and visitors being present.

The minutes of the last meeting were read and approved.

The Secretary read the names of four applicants for membership approved by the Board and to be voted on at the next meeting.

The names of Messrs. Handy and Felkel were then presented for ballot, and Messrs. Engstrom and Camp were appointed tellers. The result of the ballot showed 36 votes for each of the applicants and they were declared duly elected.

Mr. Diescher moved that a committee be appointed as requested at the October meeting by Mr. Arthur Kirk, as the latter had gone to considerable expense in regard to his paving material; the same being in use in Edinburg, Glasgow and other cities, and he thought it no more than proper that a committee be appointed to make an examination and report upon it.

Mr. George S. Davison seconded the motion with the suggestion that three members be appointed and that said committee not only report upon the character of the pavement, but also make some sketches of it and have same engrossed in our Proceedings. Carried.

The president appointed Messrs. Diescher, Roberts and Schellenberg as the above committee.

Mr. Davison moved that a committee be appointed to nominate officers for the ensuing year. It was amended, on account of the absence of the President, to read, that the President shall name the committee by mail. The amendment prevailed.

Mr. Samuel Diescher then read the paper of the evening, entitled:

"INCLINED PLANE RAILWAYS."

Inclined Planes are constructed for the transportation of passengers and commodities on grades far too steep as to be surmounted by ordinary means of travel.

The oldest type in use is the "gravity incline," found about mines and quarries situated at altitudes much higher than the point where their products are to be delivered for consumption or further transportation. This type is very frequently employed at the coal mines along the Monongahela, the Youghiogheny and the Allegheny rivers, in Pennsylvania. Its construction and mode of operation is very simple, and since it is not used for hoisting of loads but only for their lowering, the weight of the material transported thereon furnishes the motive power. Its whole outfit comprises a drum, generally constructed of wood, a braking device by which the speed of the cars is checked, and these with rope and tracks, complete the plant. It fulfills its purpose in a very efficient manner and very economically, too. Owing to the simpleness of this type, there is no inducement for us to further dwell upon it.

The steepest grade on which an electric car can travel without special auxiliaries as racks, &c., and on which an electric railway may be operated to advantage, is nine per-centum, provided, however, that this is not the ruling grade on a whole route but extends only over short sections, other-

wise the cost of hoisting car and motor amounts to more than the earnings will justify. On this account on very steep grades either a cable railway or an inclined plane will be more satisfactory than the operation by electric motor.

The characteristic features of inclined planes and cable railways lie in this, that on an inclined plane only two cars are employed and they are permanently hitched, whereas, a cable railway is not limited to a certain number of cars, and the cars are only temporarily connected with the rope. A furthur difference between the two types is that on an incline the cars travel alternately in one direction and then in the other, but on the cable road they travel in the same direction as long as they remain on the same track.

The feature of endless cables being connected with the driving drum not by a fixed attachment but by mere friction is not peculiar to this type of railways, since it had been employed during the first half of this century, on the famous Portage Road in hoisting canal boats across the Allegheny Mountains, and its principle is frequently met with on gravity inclines. The range of employment of cable railways with gripping devices is confined to grades on which the resistance from car and load do not exceed the friction in the grip, and it should by right be further confined to grades on which in a case of emergency the car may depend upon its brakes. The steepest grade on which a grip road is operated is twenty-two percentum. This is on one of the cable lines in operation in San Francisco, Cal.; it extends over one square only.

A decided economical advantage is gained in the operation of an inclined plane over that of an electric or cable road in this, that on the former the dead weights of the cars counterbalance each other, leaving only the net or paying weights to be lifted. On an electric road much power is spent in pushing the dead weight of the car and motor up a steep grade, of which none is returned on the down trip, for during the descent the brakes must be applied, which is not only uneconom-

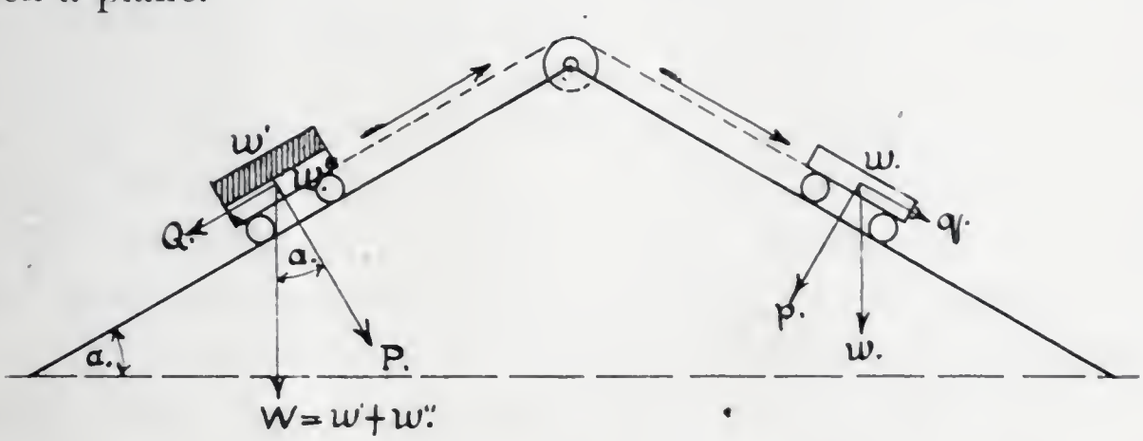
ical but directly destructive to wheels, rails and brake shoes. For these reasons an inclined plane is the most rational means of transportation between points accessible by steep grades only.

The power employed in their operation is, with a few exceptions, steam; as to the exceptions, there are in some cases electric motors applied to geared drums—where the power plant differs from the corresponding steam power plant in this, that the motor takes the place of the engines. This arrangement is in use only on inclines doing a moderate business, where the consumption of fuel and the employment of a fireman would exceed the cost of the electric current furnished by some electric railway plant. The other exceptional instance is where water is found at the level of the upper landing in such quantity that it may be used in like manner as coal and minerals in general in the operation of gravity inclines.

Recently another type was introduced which is a compromise between a gravity incline and an electric railway. It is built with single track as well as with double track. In street railway parlance it is known by the term "Balance System." It came into existence since the general adoption of electricity as motive power for street cars. So far it was used exclusively for the transportation of electric street cars on grades too steep as to be surmounted in the ordinary way. This type has no power plant of its own, but the operation is performed by the motor of the ascending car. To accomplish this the car is counterbalanced to the extent of its dead weight; in a single track plant this state is attained by a properly ballasted iron dummy car, traveling simultaneously with the motor car, but in opposite direction. By this means the dead weight of car and motor are held in equilibrium. In the case of a double track line, the necessary balance is established by another car traveling in opposite direction. The accord in travel between the one car and the dummy, respectively, the two cars, is accomplished by the employment of a rope ex-

tending from one car to the other by way of a sheave located at the head of the incline. In the case of a double track both cars are temporarily connected, each with another end of that rope, which they both drop upon their arrival at the respective terminals of the plane. With a single track and dummy one end of the rope is permanently connected with this latter and the other is picked up by the electric car when it enters the plane and is dropped again when it arrives at the point whence it can dispense with the help from the rope. As a matter of course, in the double track plant schedules must be closely observed, else the travel will be very irregular and unsatisfactory to its patrons. It is obvious from the consideration of these points, that the operating expense of such an inclined plane is very small, and were it not for its limitation by length and grade, its applicability would be very extensive, but for these and more reasons the opportunities for its employment are limited also.

Investigating the efficiency of this type, we have to examine the respective influences that dead load, live load and grades have upon its operation, the preponderance of some of which elements may be sufficient to prevent the operation of such a plane.



Let us assume in a case under consideration, that the dead weight of a car and its motor is counterbalanced with respect to its tendency to travel down grade, and, therefore, it offers no resistance to propulsion beyond rolling and journal friction. To facilitate the demonstration of the effects that grade, live

and dead loads have upon the operation, we may avail ourselves of a diagram which, for greater convenience, is made to show the two tracks on opposite slopes of one and the same hill instead of on the same slope and parallel to another. This has no bearing upon the effects of either forces or resistances, but it makes matters clearer for investigation. Now, let us suppose we have a grade of say, 25 percentum, on which a double track incline of this kind is to be built. On the left side of the diagram is represented a car supposed to be loaded, and on the right hand side is indicated another car which is empty. The loaded car is in the cource of ascension. The grade of 25 per cent. represents the tangent of an angle of 14 degrees and 3 minutes, which angle we will denote "a," the weight of an empty car to be 8,000 pounds, and the load on the one car to be 6,000 pounds. The sum of these loads is 14,000 pounds. This sum we will mark W, the weight of the empty car to be represented by w′, and the freight by w″. From trigonometric table we find, sine 14 deg. 03′ is equal 0.24, and the cosine of same angle is 0.97.

With this data on hand, and assuming that the weights are concentrated in the center of gravity of the loaded car, we indicate the action of these weights contained in W, by dropping a vertical line from that center of gravity, and in accord with the foregoing we mark it W. Now in order to get the effect this weight has upon the traction, we project a line from the same point, perpendicular to the track. This we denote with the letter P. Another line is to be projected from the center of gravity parallel with this track, and mark it Q.

We find now that the component P is equal W. cos a, equal 14,000 x 0.97, equal 13,580 pounds. This force multiplied by 0.14, the coefficient of friction between drivers and rail, we get the traction T equal 0.14 x 13,580 equal 1,900 pounds.

Now for the reaction or resistance against travel, we find, that since the weight of the empty car is counterbalanced by

another car, the freight only remains active, and therefore the reaction will be R equal w′ sine a, or, 6,000 x 0.24, equal 1,440 pounds.

Hence :	Traction T equal	1,900	pounds and
	Reaction R "	1,440	"
And T - R equal		460	pounds.

And this is the excess of traction over reaction in the case before us, not considering friction, &c.

Now let us reverse the conditions with respect to live and dead weights, and see what results we get.

Owing to the fact that the traction is a function of the combined weights bearing upon the track, and as no change in them took place, it remains as before, but the moving load producing the reaction, is in the new case 8,000 pounds instead of 6,000 that it was before. Therefore we get now,

For reaction R = 8,000 x 0.24, equal	1,920	pounds, and
For traction T, as before	1,900	"
And now the reaction exceeds the traction by	20	pounds.

This means that although grade, total weights and motive power remained as in the former case, no motion will be effected no matter how strong a moter may be employed, unless that balanced dead weight is increased.

This demonstrates the effect grades and loads have upon the practicability of these railways under special conditions. Accordingly, we may be confronted with two apparently identical cases in which grades, aggregate weights and motive power are the same, but in the one case the dead load greatly exceeds the live load and for this reason the operation of this incline may be successful, whereas, in another case in which the relation of these loads are reversed, the scheme may be a failure.

It is in order to state here, that the efficiency of such an incline may be augmented to a considerable degree if means are provided by which the motor of the descending car can be made to co-operate with the ascending car. For this end

electric communication must be established between the motormen on the two cars, so that they may understand each other as to what is to be done.

The additional traction thus obtained would be that produced by the dead weight of the descending car and its incidental live load. It will be readily seen, that in the operation of a plane of this type, opportunities will often arise when the co-operation of both motors would be of great service.

Inclined Planes as just referred to, are in successful operation at Seattle, Wash., Portland, Ore., San Francisco, Cal., Providence, R. I., Easton, Pa., and Beaver Falls, Pa.

The complications attending the equipment of passenger inclines with power plants of their own, are due to the precautions necessary to surround the operation with as many safeguards as may be made available for the prevention of accidents and for the protection of the passengers.

As a rule, an inclined plane of this type is always provided with a safety rope, that is, a rope of which each end is attached to another car, passing also around a certain device located at the head of the incline. It consists usually of one or more sheaves and a braking device, and is known in practice as the safety apparatus. This rope is not intended to be active in the hoisting operation, but it is to render service in the case that one of the hoisting ropes should break, in which instance it takes the place of that hoisting rope. According to the design of the safety apparatus, one or more band brakes are employed with necessary tightening gear, all of which render its application very effective and prompt. By the means of this device the engineer at the levers is able, in case of emergency, to either hold the cars at any point on the tracks, or let them slowly approach their respective landings. Many devices were suggested in place of the safety rope, but up to this, none was produced whose efficiency and reliability would compare with this simple but always ready means for the prevention of accident. Since the installation of inclined

planes, several instances have occured in which serious trouble was obviated by means of this rope; in some cases the passengers did not even learn that something had happened.

More recently, automatic mechanisms are employed to guard against accidents caused by sudden disability of the engineer: he may faint, or be struck by lightning, &c. These provisions consist of self-acting braking and throttling devices so constructed and arranged that if a car happens to touch a certain lever or rod, projecting from the sill of the upper landing floor, then an auxiliary throttle and a powerful air brake are simultaneously brought into action whereby not only the steam is shut off but the whole machinery is brought to a standstill.

The hoisting ropes, of which there is generally one—but in some cases two—to each car, have one end hitched to a car and the other to the drum, or drums.

The connection between drum and engines is in most cases effected by gearing. The direct connection with the crank mounted on the drum shaft is not commendable on inclines with fixed landings, because it is almost impossible to effect smooth landing of the cars with such an arrangement.

For instance, if the engines are stopped when the cars are still a couple of feet from the landing floor, and if in such a case the car at the head is much heavier loaded than the one at the foot of the plane, steam must be admitted to complete the run, but no matter how quick the throttle is closed thereafter, in many cases the expansion of the steam will be sufficient to bring the car up with a blow against the landing that will shake machinery, cars, teams and passengers, and may even cause more serious trouble.

Assuming that the majority of the inclines are not over 1,000 feet long, and that the average speed at which they run be 600 feet per minute, and therefore, the time of motion not over two minutes, whereas the pause between two succeeding runs is in most cases five minutes, in some rare ones, however,

as much as twenty minutes, it is plain that such engines have ample time to cool off entirely between runs, and for this reason they require re-heating before they can work with full efficiency. It is obvious then that the larger the engines the more heat will be wasted in reheating them after every trip, now, since direct connection of engines with the drum shaft requires larger engines because of their necessarily slower piston speed, it is evident that on this latter account also this method of applying the power is not the best for inclined planes.

On the other hand, with indirect, that is geared connection, and smaller engines the loss from condensation is much less than in the former case. The act of landing, too, is performed with more satisfaction, because with smaller engines and geared connection a full stroke of the engines causes but a comparatively small turn of the drums; whereas, with direct connection one stroke will always produce half a revolution of the drums. Another bad feature of direct connection is that at the beginning of a trip, the oscillations of the engine pistons are too distinctly felt by the passengers as to be pleasant.

Concerning the drums, it may be said that the larger their diameter the better. The same holds good in regard to the distance at which they are to be located with respect to the head sheaves at the landing. Bending around a curve of large diameter is easier on the rope than if the diameter were small. A drum of large diameter may be located nearer to the head sheaves than one of small diameter, because of its smaller width of face the angle of deflection of the rope as this travels from one edge of the drum to the other, during the process of winding, is smaller, too.

Concerning the relative costs of drums. it may be said, that whether the diameter of a drum is large or small, the capacity to accommodate the rope must be the same for any particular incline in consideration; therefore, the shell of two drums of equal winding capacity must be equal also. But the compression of the shell, produced by the tension of the rope,

is in the aggregate greater with drums of small diameter than with such of large diameter and equal winding capacity. This is due to the fact that if a rope, belt, or chain is wound around a cylinder, the total radial compression exercised by such rope, &c., for one coil around the whole circumference, is always equal the tension in the rope times twice 3.1416, and the compression the shell sustains in the direction following the coil, is equal to the tension in the rope itself, it matters not in any case what the diameter of the cylinder may be. With a drum whose shell is built up of staves, these latter are under transverse strain and must, therefore, be made the stronger the wider the drum face is, and it is very essential that their beveled sides be fitted to perfect contact, else the drum will collapse. If in a drum, shell and spiders are cast as one piece, the radial compression does not come to action and in such a case only the compression in the direction of the rope needs be provided against, which, as already stated, is the same in magnitude as the tension in that rope. In the whole, the difference in weights between drums of different diameters is for drums of like rope bearing surfaces too small to be considered, especially if we take into account that in the case of a larger diameter we get a smaller shaft, can locate the machinery nearer to the head sheaves, have narrower foundations and need less ground for the accommodation of the power plant. As to the largest diameter commendable in any particular case, we must consult the shop facilities as well as those for shipment, but up to twenty feet, there should be no trouble on that score.

Regarding the contrivances employed for the control of the operation, there are in addition to the safety apparatus and self-acting mechanisms, the links, throttle, hand and power brakes. To demonstrate the necessity of these devices, I call attention to two accidents of which one was accompanied by fatal results and the other came very near to it. I have reference to an instance that occurred about ten years ago in Cincinnati, O., and the other about twelve years ago in Pittsburg.

The cause of the first accident named, was, that a small chip of cast iron, not over half an inch square by three sixteenths high, got between the throttle valve—which was of grid-iron pattern—and an edge of a port, and thus prevented the shutting off of the steam from the engines. The slide valves were not balanced, being therefore under full steam pressure, the engineer was unable to reverse the engines or bring the links to the dead center. Owing to this circumstance, the ascending car was tightly drawn to the landing when it arrived there, and although it was thereby brought to a stand still, the ropes remained under the full effect of the engines. On account of a peculiar construction of the car doors and the landing, with which I am not familiar, the door could not be opened in spite of the efforts of the employes on that landing. After some seconds, a member of the investigating committee says at least half a minute, the connections under the car were drawn out, the car went down the incline with about a dozen passengers. On arriving below it was shattered, several passengers were killed outright and the others all seriously injured.

This accident could have been prevented in two ways; first, by the use of an auxiliary throttle, and second, by either having the hitching beams so constructed that they cannot be destroyed by any strain the hoisting rope may stand, or by having the safety rope hitched to a different member of the truck frame.

The accident that occurred in Pittsburg came about in this manner :

About twelve years ago, during one of the trips, it happened that as one of the cars was approaching the upper landing, the engineer, whose attention was apparently distracted from his duties, failed to close the throttle, the car continued in its ascension until it hit the landing and lifted the floor, which was not very substantially constructed, and with this also the engineer's cabin. At this juncture the motion of the engine was reversed. Whether this was brought about by the

action of the engineer or through the lifting of the floor was never satisfactorily ascertained. However, the east car went down with extraordinary speed. The engineer left his cabin through the window. He became incapable of intelligent action from sheer fright. When the west car, carrying two men and a two-horse team, arrived at the upper landing it was drawn up to a point where the hitching screws projected beyond the head sheaves, and being thus subjected to transverse strains, they snapped. At this instant the two men jumped from the car to the ground, a distance of about fifteen feet. None was hurt. The car became entirely disconnected, it flew down upon a grade of near seventy-two percentum, the team was thrown off, the wagon shattered and the animals killed. As this car arrived in the pit it was completely demolished and its debris went in all directions.

After all the rope from the east car was uncoiled from the drum, it began to wind up in the opposite direction, thereby starting this car upon another ascension, but as it reached a point about forty feet from the pit it collided with some fragments from the other car, and in its already damaged condition it broke loose also and dropped back into the pit. The machinery was still running; the ropes coiled upon the drums, with their loose ends flying about like whips in the air, until the engineer of the passenger incline belonging to the same corporation, ran into the boiler house and there shut off the steam.

This accident could have been prevented by the use of an auxiliary throttle, a separate hitching point for the safety rope and a more substantial construction of the landing.

In both cases just described an air brake of proper strength by which the machinery can be stalled with steam on would have been of great service too.

The endless rope driving system is employed on inclined planes in cases where the track is so long that the whole rope cannot be coiled upon a drum unless this drum is excessively large in diameter and face, or that double or multiple wind-

ing would have to be resorted to. The multiple coiling is not commendable owing to the injurious effect it has on the rope, but if adopted, the safety apparatus, in case such is to be installed, will be more complicated and the more so the more layers are coiled upon the drums. To explain this, let us consider an incline on which the hoisting rope is of such length that the drum or, if there are two of them, both must be covered twice so as to accommodate this rope. In other words, the drums will contain each a single layer of rope at the moment when both cars stand abreast at the half-way point on the tracks. From this point on the drum doing the hoisting makes double layers. But since by reason of the first windings the diameter of the drum was increased by the amount of twice the thickness of the rope, the circumference is increased by six times the diameter of that rope. It follows then that with every revolution of the machinery this particular drum takes up that much more rope than the other drum pays out. For better illustration, let us say the thickness of the rope be one inch; then for every revolution the ascending car travels six inches more than the descending car, and in case that there were twenty coils to the face of the drum, by the time the two cars arrive at their respective landings, the upper car advanced over the lower one, six times twenty inches, equal ten feet. From this it becomes evident that if a safety rope is to be employed in connection with this kind of winding, the safety apparatus must be so designed that it will adjust itself according to the variations in the speed of the cars. For as soon as the ascending car passes the half-way point on the plane and begins to travel at an increasing speed, it tends to shove before it the safety rope at the same speed at which it travels, but since the car on the other track travels at a slower speed it produces a slackness in the safety rope amounting—in the present case—to six inches for every revolution of the drums, and thus by the time that both cars are come to land, the aggregate slack in safety rope

will amount to ten feet. As said before, these ten feet of rope must be taken care of by the safety apparatus and kept in uniform tension, otherwise this rope will not properly perform its functions, which is to take the place of a hoisting rope in case that one of them should for some reason fail. It is obvious that at such an occurrence the shock produced by the car running loose a distance of ten feet, until the safety rope becomes stretched, must be very severe on ropes, car, and passengers.

The same cause that produces slackness in this rope from the time on that the ascending car passed the half way point, produces contrary results when the direction of travel is reversed. For as soon as the upper car starts on its down trip, for every revolution of the machinery it will travel six inches further than the ascending car and will for this same reason require that much more safety rope than is yielded by the slower ascending car. Now, in case that this difference cannot be compensated by drawing upon the slack previously stored in the safety apparatus, it will occur that either the descending car will not travel faster than the other car permits it to go, and then its hoisting rope will slacken, or, if the descending car is loaded heaviest, the hoisting rope on the ascending side must get slack.

In case it is decided to adopt the endless rope system, two points demand our attention, namely, the adjusting device of the hoisting rope and the employment of the safety rope in connection with above system. The first mentioned device is of a different design on inclines, owing to their fixed landings, from what it is on cable railways in which the sole purpose of the tension apparatus is to keep the rope stretched, whereas, on an inclined plane its object is to keep the hoisting rope adjusted with respect to the length of the track, It is to be remarked concerning the landings of an incline, that the distance between them is constant while the length of the rope is continuously changing. These changes are due to the gradual

contraction of the diameter of the rope on account of the tension, and also to the effects of variations in the temperature of the atmosphere. Both these effects are more conspicuous on long inclines than on short ones.

Unless these variations are provided against, the operation of such an incline will not be satisfactory. This will be experienced more on team inclines than on those for passenger travel, because with teams it is necessary that the car be brought close to the edge of the landing, otherwise there would be danger of the horses stepping into the gap, it also interferes with driving on or off the car. To comply with this requirement of team inclines, and such engaged in the transportation of electric cars, it is essential that the ropes be kept at proper lengths, particularly the hoisting rope, for if this happens to be too long, the lower car will touch its landing while the upper car is away off his. And in case the hoisting rope were too short the upper car will press against the platform while the lower one is still away from its landing. All of this shows conclusively that in a case like the foregoing one, means must be employed by which the adjustment of the hoisting ropes can be done with promptness and least possible manual effort.

Another feature with the endless rope hoisting system is that if a safety rope is used, this latter is apt to seriously interfere with the operation. This trouble arises in the following manner:

On all inclines with safety ropes the descending car, when it leaves its landing, is counterbalanced to the extent of the weight of the safety rope stretched over the other track. In other words, that car loses so much of its tendency to travel downwards as it takes to make the safety rope to travel upgrade. The machinery acts only upon the hoisting rope and has no direct effect on the safety rope. For this reason the latter begins to move only after the car at the upper landing began to descend. Hence, in case that the weight of this car were less than that of the safety rope, the car would not move

at all owing to the resistance offered by that rope. Assuming that in a given case the weight of the car were fully ample to cause the travel of the rope, it is evident that whatever energy there may be required to produce this motion will result in a corresponding reduction of that car's own downward moving tendency; that is to say, the strain that car would otherwise exert in the hoisting rope is reduced by an amount equal to the resistance the safety rope offers against its being hoisted up the incline. It is of importance now to find whether the excess of the car's weight over that of the safety rope will suffice to produce the friction necessary to prevent the hoisting rope from slipping on the drum. The elements that bear upon this question are, besides the difference in weights just discussed, length of plane, uniformity of grades or their respective steepnesses at the landings.

The friction between hoisting rope and drum is in the endless rope hoisting plant the only means by which this rope is made to stick to the drum's surface. This friction is a function of the number of coils slung around the drum and of the tension in the hoisting rope on the side of the outgoing car. Though this friction may be increased very materially by laying more coils upon the drum yet there are reasons why this is not resorted too. Namely, in such a hoisting plant there are always two drums placed tandem, so that the rope is wrapped over both simultaneously, in a manner that each of these drums has only its outer half covered. But as this rope is coiled over these drums under heavy strain, in some cases as high as twenty thousand pounds, it is plain that by continued wrapping the pressure in the journals of the drum shafts grows so excessively that the operation of the machinery under such conditions becomes impracticable. It also necessitates heavier shafts and is injurious to the rope, too. Experience proved that six half wraps on the working drum are fully sufficient to answer all practical requirements.

Of the drums employed in connection with an endless

rope there are two types, the "solid" and the "compensating" drum. The first named has the grooves turned into the rim, and the other has smooth rims on which as many wrought iron rings are mounted as there are grooves required. These rings are laterally held in position by two flanges of which one is fixed and the other is bolted on by means of studs projecting from one side of the rim. Each of these rings has a groove turned in, and they may be laterally pressed against each other and the fixed flange by tightening the nuts on the studs. In case that solid drums are employed, only one of them is geared and the other serves as an idler. Each of them has six grooves but because those on the idler not being in service, only those on the fixed drum are actually working. On the other hand, with compensating drums generally both of them are geared, on account of which three grooves on each drum produce the same traction as the six grooves on each of the two solid drums; at the same time the rope is subjected to only half as many bends, the bending moment in shaft is smaller, and likewise the journal friction is less than with solid drums of equal capacity.

The cause that led to the employment of the more expensive compensating drums is that it is next to impossible to turn two or more grooves into a rim so that the diameters measured at the bottom of the grooves shall be equal for all of them. It follows from this that the circumferences along these groove bottoms must correspondingly vary too, and that if ropes are laid into the grooves and the whole made to revolve, each of the grooves demands another length of rope. For further illustration let us suppose that the groove upon which the rope enters the drum, as it comes into the power-house from the track, were one-sixteenth of an inch smaller in diameter than its neighbor, then it would occur that this groove of the larger diameter would need three-sixteenths of an inch more rope than the first one is able to deliver by one revolution of the drum, and therefore, it will happen that either the rope wrap-

ped on the first groove slips that much, or that the rope in the second groove stretches a like amount. Both of these occurrences are detrimental to the rope as well as to the drum. It is obvious that what happens between two grooves by reason of inexactness will be repeated in the other grooves and the whole must necessarily result in the untimely destruction of the drums and ropes and also in much greater resistance and general wear and tear in the operation than if provisions are made for the automatic adjustment of these descrepancies.

In compensating drums all this trouble is obviated, the grooved rings are independent of each other, the differences in their circumferences are adjusted by the rings themselves on account of their capacity of slipping whenever the tension in the rope attains a certain limit, fixed by the greater or lesser strain with which the nuts on the studs are tightened, whereby a corresponding lateral pressure is exercised upon the rings. By this and the friction the ropes produce in pressing the rings against the face of the drum rim, all of the friction is provided that the operation of the machinery demands.

With respect to the effect of a safety rope in counterbalancing part of the weight of a car under circumstances as mentioned before, it is in order to say, that its employment in connection with the endless rope device, is practicable under the fulfillment of either one or both of the requirements herein set forth, namely, if the incline is not much over two thousand feet long and the grade is uniform and the cars substantially constructed and heavy, the safety rope may be employed without trouble during operation. The other condition is, that if the length of the track is much over two thousand feet, the mere uniformity of the grade may not reach to attain the desired result and then if the grade varies it must do this in a manner that the steepest grade is at the upper end and the lowest at the foot. Should this condition not prevail then a tail rope must be employed that is of same weight as the safety rope. This is to be so connected with the cars that it will bear

the same relation to the cars with respect to their rear as the safety rope to their fronts. The adoption of this last means affords a perfect counter-weight to the safety rope, whereby the strain required to produce the friction between drum and hoisting rope is fully provided.

A subject of very great importance in connection with the operation of inclined planes is the wire ropes. The deterioration of a wire rope is directly in proportion to the wear it produces in a sheave it travels over. If among two sets of sheaves performing the same functions under the same conditions one set shows more wear than the other, then the rope passing over this particular set will also have suffered more than the one passing over the sheaves less affected. Sheaves will wear, no matter how carefully they may be set and how good the material and workmanship may be. But such wear is considerably increased if a rope deflects from the course it would travel if it followed the direction indicated by the sheave. This condition prevails in all cases where the rope is coiled upon a drum during which process it constantly alters its course, and in doing so assumes different radial positions resembling the ribs of a fan, having its center of radiation in the point of contact with the sheave. And since these deflections occur under more or less pressure between the surfaces in contact it necessarily causes a displacement of particles of metal, resulting in a gradual deepening of the groove. It is to be noted that whenever a rope deflects from the course of a guiding groove, the point of contact acts as a fulcrum for the swinging motions of that rope, and if these deflections take place under any pressure at all abrasion must follow, too. Any difference in the hardnesses of rope and sheaves will have its effect upon the relative wears, but it will not protect the harder one of them from eventual disintegration.

With a sheave or drum of very large radius, and a short arc to cover, at a low strain and slow speed, there is little

difficulty for the wires to accommodate themselves to their altered relative positions, but under high strain, at high speed, a comparatively small radius of curve, and a long arc to cover, this adjustment does not take place as it should with regard to the preservation of the rope, but it is forced. In consequence of this, not only abrasion occurs among the wires, but they have also a tendency to squeeze each other out of shape, owing to which ropes worn out under heavy strains show that the wires, particularly those of the inner strands, are pressed into hexagonal form.

The abrasion and deformation can be obviated to some extent by a liberal application of a lubricant, which has the two-fold effect, that it facilitates the re-adjustment of the wires, and protects the rope from corrosion.

As to wire ropes in general, their make and service, more may be said than our time and space permit. We must therefore confine ourselves to the consideration of the most important features.

As a rule all ropes employed on inclined planes engaged in the transportation of passengers, teams, &c., are of the very best materials and make. Up to this, all steel used in the manufacture of high grade ropes is imported from England. A few of the American rope manufacturers import the finished wire; they say that a better quality of wire is made there than here. One of the foremost American rope making concerns stated upon written inquiry, that they have spent over $100,000 in experiments with domestic steel but their efforts did not meet with success.

According to my own experience in using wire ropes in connection with inclined planes, I feel justified to state that the best results as to long wear and strength were obtained with ropes made of crucible steel wire of an ultimate tensile strength between 160,000 and 170,000 pounds to the square inch of wire section, and four per cent. elongation in twelve inches between jaws of testing machine.

In the following is presented the history of a set of ropes for an inclined plane. Beginning with the tests of the wires of which these ropes were composed, then showing the test of the rope as soon as the wires were assembled, then follows the record of their gradual deterioration, and, finally, the tests of the worn ropes after they were thrown out of service. The table referring to the wires is arranged according to maxima, minima and average. The wires were tested during the 19th and 20th of March, 1891. The report says: "Tested 60 pieces in all; with the following results: In elongation five pieces only gave less than 3.5%, six between 3.5% and 4%. It is highly probable that these pieces were cut from too near the ends of the coils, as the second pieces of the same coils gave better results. A few of the twist tests were low, and these few low ones were caused by clip marks made on end of wire in process of drawing. Better results were always found in taking pieces from the same coil further from the end of the wire."

W. G. No.	Dia. inch.	Ult. tens. pr. sq. in.	Elong. in 12 ins.	Twists in 8 ins.	
12,	0.113	184,000	5.6%	28½	
10,	0.139	194,000	5.6%	21	Maxima.
9,	0.155	183,000	5.2%	17	
12,	0.105	158,000	2.3%	9	
10,	0.131	168,000	2.8%	3	Minima.
9,	0.150	170,000	3.9%	8	
12,	0.109	171,700	4.2%	22.4	
10,	0.134	176,300	4.6%	16	Average.
9.	0.148	177,700	4.7%	15	

The average ultimate strength of individual wires was: No. 12, 1,600 pounds; No. 10, 2,491 pounds and No. 9, 3,069 pounds.

Each of these ropes was two inches in diameter, had six strands and each strand contained 19 wires, all laid around a hemp centre.

The composition of this two-inch diameter rope, based upon the average strengths of wires according to above test report is as follows:

Each strand consists of 6 wires,	No.	9@3,060 lbs.	equal	18,360 lbs.
7	"	"	10@2,490	"	"	17,430 "
6	"	"	12@1,600	"	"	9,600 "
Hence aggregate strength in 1 strand						45,390 "

And the strength of the rope composed of 6 strands:

Six strands at 45,390 pounds equal 272,340 pounds.

According to statements of rope manufacturers, the strength of a finished rope is ten percentum lower than the aggregate strength of the wires of which it was made. Therefore this particular rope should stand an ultimate strain of 272,340 less 27,234 equal 245,000 pounds in round figures, but when put to test it parted under a strain of 222,000 pounds, which is considerably below what was expected. The piece tested was twenty feet long between the sockets. The test was made at the works of the Phœnix Iron Company. Upon consultation with the manufacturers of this rope, they explained the excessive difference between the strength of the wires combined in that rope and that of the rope itself in this manner. "That there is always more or less of a disturbance in the uniformity of tension on the strands when the fastenings are put on; some of the strands are slacked off a little and this, of course, throws an undue strain upon the remaining ones."

There were three of these ropes made, and they were used on an inclined plane. One served as a safety rope, and the other two as hoisting ropes. This incline is engaged in the transportation of passengers, and teams of ordinary weight, the cars are twelve feet wide and twenty-four feet long. Owing to the great steepness of the grade, near 72 per cent., a passenger cabin could be accommodated under the floor for teams.

The operation commenced on the first day of June 1891. A general inspection of the incline is made every two months. At these occasions particular attention is paid to the state of

the ropes. Namely, those points on the ropes are looked for that show the most wear and contain the greatest number of broken wires in a length of twelve inches. Grade of incline 72 per cent. Least constant tension in each of the two hoisting ropes is 9 tons; highest occasional tension 15 tons. Up to March, 1894, the counts of broken wires were made while the ropes were on the drum and at rest. After that date all counts were made with the ropes stretched out on the tracks.

Date of Inspection.	N. Hoist. Rope.	Safety R.	S. Hoist Rope.
Oct. 9, '93.	2	3	7
Dec. 30, "	2	3	9
Mch. 20, '94.	4	4	14
May 9, "	17	8	30
July 31, "	17	21	46 disc'd'd.
Oct. 9, "	19	25	Traveled 20,000
Dec. 15, "	24	31	miles.
Feb. 27, '95.	25	32	
April 27, "	28	34	
June 25, "	30	46,	discarded, had travel-
Aug. 29, "	30		ed 38,000 miles.
Oct. 29, "	30		
Dec. 27, "	30		
Feb. 28, '96.	32		
April 30, "	32		
June 26, "	32		
Aug. 27, "	32		
Oct. 24, "	33 had traveled 51,000 miles, still in service.		

As seen from this record, the south hoisting rope served only three years when it had to be thrown out on account of advanced deterioration; it showed then 46 broken wires in a length of 12 inches where most affected. During its life it traveled about twenty thousand miles and performed work equal to 180,000 ton-miles. After it was taken out,

two pieces of it were prepared for testing; they were made twenty feet long between the sockets, and were selected from the worst sections found in the whole rope. Tests were made at the Phoenix Iron Works, October 29, 1894. Test pieces were marked respectively, "A" and "B." Piece "A" contained a section which showed 42 broken wires within twelve inches at the examination of preceding June, and piece "B" contained a section that showed 46 broken wires in twelve inches at same examination. The report says:

"In piece 'A' four strands broke at 168,000 pounds strain. These strands were numbered respectively, 1, 3, 4 and 6. Three wires of strand No. 6 pulled out of socket."

"In piece 'B' three strands broke at an ultimate strain of 195,000 pounds."

During June of 1895, the safety rope, too, showed considerable sign of deterioration and, therefore, this also was thrown out of service and likewise subjected to a final test. Length of test piece, and place of test was the same as in the preceding case, also the number of broken wires found at its last inspection was 46 in twelve inches, just as before.

The strands were numbered, and strands Nos. 1 and 2 broke at a strain of 108,000 pounds, No. 5 next, at 72,000, then No. 6 at 54,000, No. 3 at 42,000, and No. 4 at 27,000 pounds.

Report says further: "No wires pulled out. Elongations measured by travel of piston and were taken after application of load and represent the stretch between the breaking of one strand and that of the next. The sum, therefore, gives total elongation at the breaking of last strand. These elongations were with respect to the order in which the strands broke, 0.22 feet, for first two strands, then, 0.16 feet, 0.09 feet, 0.101 feet, and 0.106 feet, and from this the total elongation was 0.677 feet."

The ultimate strengths exhibited by these old ropes when tested, are surprisingly high, and especially so if we take into

account in addition to the deterioration from broken wires, that resulting from the abrasion and deformation of the wires. Assuming that those tests are correct, the high results must be sought in the fact that the breaks of the wires are not arranged in a ring around the rope, but are generally well scattered, and only in a few instances are there as many as three breaks found close together. Hence they overlap each other and, as it were, "break joints"; thus the rope approaches in its make-up that of a rope made of fibres, as cotton, jute and hemp. In such ropes the strength lies secondarily in the friction by which the slipping tendency of the fibres is counteracted. With long fibres, like those of hemp, the friction exceeds the absolute strength of the fibres.

I have here a sample of an old rope of originally two inches diameter. It served on a freight incline, traveled about 45,000 miles under a minimum strain of nine tons and a maximum of 15 tons. It must, therefore, have performed at least 450,000 ton-miles work.

One of the three ropes above considered had to be replaced after three years service, the second after four years service, and the third one is still in action, having already served five years and five months, and traveled about 51,000 miles, whereas 50,000 miles is considered extraordinary good service on an inclined plane.

According to the report on test of the discarded safety rope, the different strands parted under following strains:

Strands	Nos.	1 and 6	at	108,000	pounds.
"	"	5	at	72,000	"
"	"	2	at	54,000	"
"	"	3	at	42,000	"
and "	"	4	at	27,000	"

Above results show that these strands were not of like strengths, for, by respective subtractions it occurs that the combined strength of strands Nos. 1 and 6 were 108,000, less 72,000 pounds equal 36,000 pounds, and in the absence of

specific data in relation to their individual strengths, the next best thing we can do in this instance is to divide the combined strain evenly between these two strands, and then we get for each of them 18,000 pounds. Accordingly we obtain the following strengths for each of the six strands of that rope:

Strand No. 1	18,000	lbs.
" " 6	18,000	"
" " 5, 72,000 less 54,000	18,000	"
" " 2, 54,000 " 42,000	12,000	"
" " 3, 42,000 " 27,000	15,000	"
and " 4, which broke last	27,000	"
Total	108,000	lbs.

From the test report on the strengths of the individual wires made at the time the ropes were ordered, March, 1891, we learn that the combined strength of seven wires forming the core of the strand, is 17,430 pounds. Deducting from this the usual ten per cent. loss of strength on account of twisting, we get 15,700 pounds in round figures as the net strength of a core strand.

This leads to the following deductions:

First. That strands Nos. 1, 6 and 5 were each 300 pounds stronger than the mere core strand.

Second. That strands Nos. 2 and 3 were each weaker than their core strands would have been if in sound condition.

Third. That strand No. 4, which broke last, was 11,300 pounds stronger than its core strand alone would have been if perfectly sound. And we may further conclude, that with the exception of strand No. 4, all strands had their outside wires considerably weakened, and that strands Nos. 2 and 3 must have had their core wires weakened also. For each of these two strands stood less of a strain than their cores would have sustained if uninjured. And finally, the strength of strand No. 4 indicates that its outside wires must have been in a much bet-

ter state of preservation than those of the other strands, for, it stood 11,300 pounds more of a strain than its core would have sustained when in its most perfect condition.

With respect to strands Nos. 2 and 3, it remains undetermined to what extent the core wires were affected, because it is impossible to ascertain what portion of the test strain bore upon the skin and the core wires respectively. From all of this we glean the information that, although in many cases relating to badly worn ropes, the core wires may be in comparatively sound condition, it is not advisable to accept such a state as the rule, because there are no means by which we can obtain positive knowledge of the true condition of such core wires in any given case.

The injury to which core wires are most exposed is deformation of their sectional form. The constant tension in the outer wires produces a tendency to contract the area of the section of the strand, and thereby pressure is exerted upon the wires forming the core. This pressure is considerably increased when the rope bends over a sheave, in which case the strand, and certain of its wires on the convex side of the arc, come under special high tension and at such occasions the core wires must sustain excessively high compression. In consequence of this they become deformed; they assume a hexagonal shape and stretch in proportion as their sectional area is reduced. From my own observations in examining worn out wire ropes, I found that in general the core wires remained whole as to length, but they were invariably changed in respect to their sectional area.

Therefore, on inclined planes and on all railways in operation on steep grades, by the aid of wire ropes, great care should be exercised in regard to the condition of the rope; and whenever it is found that within the length of the pitch of a strand about 40 per cent. of the wires are broken, it is time to have the rope thrown out and a new one put in its place. The reason for selecting the pitch as a unit of length is, that within

such length all outside wires are once exposed to abrasion and extreme bending, and further, that when a wire is so broken that its length does not exceed that of one twist of the rope, the friction by which that wire is held from slipping is not sufficient to make it bear any considerable portion of the strain it ought to bear.

DISCUSSION.

THE PRESIDENT. You have all heard the very interesting paper. Is there anything that you wish to say or ask Mr. Diescher? We are ready for remarks or questions on inclined planes.

MR. NAEGELEY. I would like to ask Mr. Diescher what he considers the most reliable test for wire rope?

MR. DIESCHER. The most reliable test is that made of the wires, because it tells all about the qualities of the material of which the rope is to be made. A test of the finished rope gives the ultimate strength of the rope but nothing else. A rope may stand a very high tensional strain and yet be too brittle for its intended purpose.

A MEMBER. I would like to ask Mr. Diescher if he ever examined rope to see how many inside wires were broken, or if the broken wires are all on the outside?

MR. DIESCHER. The breakage in wires occurs, as a rule, on the outside. I untwisted rope that was much worn and badly broken, yet the seven inner wires were unbroken, although, in some cases, very much worn and altered in section.

MR. DEFORD. Inside wires probably break from abrasion, not having friction on them?

MR. DIESCHER. The breaking of the wires is caused chiefly by brittleness. Were it otherwise, the fractured ends would show some reduction of section and would stand apart, but such is not the case; on the contrary, no taper is seen there, and the ends remain in close contact for several weeks. The fact is, that a new break is almost invisible until oil gets

into it, and it is not easily noticed by touch either. The surfaces of the breaks are as even as when sheared. The brittleness arises from two sources, first: from the alternate bending and straightening of the rope at the sheaves, and second: from the vibrations to which it is subjected while traveling over the track pulleys. These latter are always more or less eccentric, on account of which the rope is alternately raised and dropped with every revolution of every pulley it goes over. The effect of these vibrations grows with the tension and the speed at which the rope travels.

Mr. Naegeley. Mr. Diescher, as I understand, recommends the testing of the single wires. I have in my experience of testing wire rope failed to find satisfactory results. Several months ago I made about sixteen full size wire rope tests including $\frac{3}{4}''$, $\frac{7}{8}''$, $1''$ and $1\frac{1}{4}''$ diameters, of English and American make, all of them falling short of the manufacturer's own claim of from five to ten tons. The material was claimed to be cast steel.

Mr. Diescher. The manufacturers say that the strength of a rope is ten percentum less than the combined strength of all the wires of which it was made. I am unable so state whether this is based upon experience or whether it is merely an assumption. To obtain reliable data about the strength of a wire rope it is necessary that the contrivance by which that rope is to be fastened to the testing machine shall be very carefully prepared and attached. The usual method of fastening the ends of the test piece into sockets with tapered holes, does not insure uniformity of tension in all of the strands of that rope.

Concerning the steel used in the manufacture of wire, we know that there are many grades of crucible steel, and that therefore, the mere fact that a rope is made of crucible steel does not signify that it must necessarily be a strong rope.

Mr. Naegeley. Why are three different sizes of wire used in one and the same rope?

MR. DIESCHER. The reason for this is that a strand made of wires of same size will not be round but hexagonal in its cross section. If we arrange six wires around a central one, all of same diameter, they will form a hexagon. It matters not how many more layers of same size wires we may pile on, the cross section of the whole will always be that of a hexagon. By using three sizes of wire, so that the medium one is used for the seven core wires, and the two other ones in such a manner that the smaller lie on the corners and the large wires between the corners of the hexagon, the whole will be round. A round strand is less subject to abrasion than one exposing corners.

A MEMBER. What is the best lubricant for a rope of this kind, and would it increase the durability of rope if the sheaves were lined with hard wood?

MR. DIESCHER. Rope manufacturers recommend a mixture of linseed oil and pine tar, but almost every one using ropes has an opinion of his own on this subject. At some inclined planes they skim the oil off the drainage from the exhaust of the engines. Some use Mica Axle Grease. A few years since the Standard Oil Co. were in the market with a special compound for the preservation of wire ropes, which is much praised by the people who use it.

Concerning the effect of wood-lined sheaves on the durability of wire rope, it may be said that in cases where the rope does not bear very heavily on the lining, and the tension is moderate, the life of the rope is thereby extended, but not to a degree whereby the expense and annoyance of relining would under all circumstances be outweighed by the increased life of the rope. It is not so much the external abrasion of the rope from contact with cast iron as the bending followed by brittleness and internal wear that brings on its early destruction. In former times grooves used to be lined with various kinds of material, as wood, leather, rubber, hemp rope, &c., but now lining is not used to any considerable extent, except in the

transmission of power by means of fast running light wire rope. With heavy ropes at high tension, lining wears out too fast to afford an economical advantage over ordinary cast iron sheaves with turned grooves.

A MEMBER. Are ropes not thrown out on account of having performed a certain amount of service?

MR. DIESCHER. The amount of work performed by a rope does not determine its condition or reliability in respect to further service. One rope may have done much work and still be in serviceable condition, whereas another one may wear out after comparatively short service under precisely the same conditions as before. I know of a case that came within my own observations in which one set of ropes served eight years and the succeeding one was badly worn and broken up after only eight months use, the conditions were the same in both cases.

MR. SWENSSON. Has the stretch any thing to do with it?

MR. DIESCHER. The stretch is due mostly to a reduction of the diameter of the rope, brought about by internal wear in the hemp center as well as among the wires themselves, caused chiefly by the bending around sheaves under high tension.

MR. SWENSSON. Does not the breaking of the wires increase the stretch?

MR. DIESCHER. The breaking of the wires does not materially add to the stretching of the rope unless it has very far advanced. For the wires do not part soon after breaking occurs; the ends butt against each other and remain so for a considerable time. This would be different if the breaks had been caused by pulling strains, which in such a case would have had to exceed the elastic limit of the wires near the break.

MR. SWENSSON. Speaking about sheaves for carrying rope, we have found that leather lining is best for wearing qualities.

MR. DIESCHER. Leather is a very good material to line sheaves with, where power is to be transmitted from one shaft to another, and a high coefficient of friction is desired to pre-

vent slipping. For finished cast iron and steel this coefficient is 0.15, for wood 0.17, for leather and rubber from 0.19 to 0.20.

MR. SCHELLENBERG. Is there nothing to be said in favor of iron ropes any more?

MR. DIESCHER. Iron ropes are now very little used for hoisting purposes; they are too cumbersome and expensive when compared with steel rope of equal capacity. For instance: A one inch diameter steel rope stands 33 tons, costs 19 cents per foot and requires a 4 foot diameter sheave. An iron rope of the same hoisting capacity is $1\frac{3}{8}$ inches in diameter, costs 31 cents per foot, and requires a sheave of 6 foot diameter. Aside of this, an iron rope is much more subject to wear on account of its softness, than a steel rope.

MR. SWENSSON. Have you any information in regard to the smallest diameter a sheave should be for a $\frac{5}{8}$ inch rope?

MR. DIESCHER. Until a few years ago the rule was to allow one foot sheave diameter for every quarter inch rope diameter. Since then the rope manufacturers concurred on demanding larger minimum diameters. What this is to be can be found on every price list of wire ropes. On derricks much smaller sheaves are employed than under ordinary conditions, because, on the one hand it is very inconvenient to have large sheaves attached to a mast head or boom, and on the other, small size wire ropes are too cheap when compared with hemp ropes of same capacity as to impress the necessity of employing special means for the preservation of the rope.

MR. RUHE. Has not the increase been brought about by the use of steel instead of iron rope?

MR. DIESCHER. According to the manufacturers' list, for ropes of same diameter, whether iron or steel, the sheaves are of same diameter.

Adjourned.

DANIEL CARHART,
Secretary.

CHEMICAL SECTION.

The regular monthly meeting of the Chemical Section of the Engineers' Society of Western Pennsylvania was held in the lecture room of the Society, 410 Penn Avenue, Pittsburg, Thursday evening, Nov. 19, 1896. President J. M. Camp in the chair. The meeting was called to order at 8.30 P. M. Twelve members and eighteen visitors were present.

The minutes of the last meeting were read and approved.

Dr. E. S. Johnson, for the Committee on Chemical Literature called the attention of the members to a number of interesting articles in recent chemical journals.

The president appointed the following committee to report on nominations for officers of the Society for the ensuing year to report at the December meeting: Mr. Wm. H. Coster, Mr. Gustave Mueller, Mr. Geo. O. Loeffler.

Mr. W. E. Garrigues read the paper of the evening, entitled, "American Utilization Processes of Garbage Disposal."

AMERICAN UTILIZATION PROCESSES OF GARBAGE DISPOSAL.

The absolute necessity for public disposition of town refuse—more especially of garbage proper—should, I think, scarcely be questioned. There are, however, degrees of this necessity whose relative positions are determined by several factors; chief among which is, of course, the common intelligence of the population. The fuel consumed in its homes has also a bearing on the question, since in exclusively coal burning cities much of the most objectionable refuse can be, and often is, consumed at once in the kitchen range.

Obviously individual intelligence in matters of house sanitation is apt to be localized in a large city, so that in absence of free collection of refuse very varying conditions will be presented by different districts; furthermore, forced economy in household expense is certain in many cases to determine the

frequency of removal of the accumulations. Probably the most unfavorable conditions are a laboring population in a gas burning town.

On the other hand we have had exemplified in the city of New York an aggravated case of dire failure in public disposition of the collected house refuse. For many years this was dumped from scows into the waters of the lower bay from where the tide and currents soon distributed it along the otherwise magnificent bathing beaches of Long Island and New Jersey—much to their disfigurement—and slowly but surely filled with it the deep channels of the magnificent harbor.

The two chief principles of garbage disposal—destruction and utilization—it is not the province of this paper to discuss relatively. Both have their merits and local conditions must always cast the deciding vote between them. The former is essentially an engineering problem while the application of chemistry is hardly less important to the latter. The fire destructor produces, of course, an ash only, and as this has no commercial value, disposal by cremation is a total loss of both substance and expense. The utilization scheme on the other hand—as its name indicates—seeks to recover from the refuse, products of distinct value. These are, to-day, grease and manure—what may be the possibilities of the future cannot be predicted. One grave objection to utilization schemes is the seemingly general disposition of city governments to let only short time contracts, the first cost of plant being so much greater than for destruction. These contracts are for terms varying from one year in Philadelphia to ten years in St. Louis, with an average of only three or four years. Especially in the chief centers of population a 30-year contract would be more reasonable, and would, no doubt conduce to lowering the annual cost to the city.

It is my intention to present in the following paper a brief account of the various methods in use in this country for extracting grease from garbage and obtaining the solid residue

in a salable condition, either as a complete fertilizer or as tankage for use in compounding such a fertilizer. A few of these processes have been described singly here and there in different journals but not infrequently with such grave errors that the description was utterly valueless—perhaps even harmful—to the seeker after facts in a new and as yet undeveloped field.

In numerous cases the local contractor, at first carried away by the contagious enthusiasm of a mistaken, even though honest inventor, has had to learn the costly lessons of experience; hence in naming the city or cities employing any one system—likewise in giving working details—it must be borne in mind that many garbage plants are—even where they have been located some years—still in the experimental stage, and that vital changes are frequent, even to the possible extent of abandonment or entire reconstruction of principle. In the instances where such changes have come to my knowledge, mention will be made of the fact.

The different systems will be divided for convenience into three classes, according as they vary in fundamental principle, viz.:

A. Grease extracted by steam.
B. " " " sulphuric acid.
C. " " " naphtha.

CLASS A.

Arnold system. Philadelphia and New York. (The contract for New York was let during the present year and I am not informed as to the date operations have or will commence.)

The garbage is dumped from the wagons into a horizontal conveyor discharging into a bucket elevator. This deposits it on the upper floor again into a conveyor by which means it is discharged into the digesting tanks. These are upright steel tanks of five to six tons capacity and here the material is subjected to live steam introduced at the bottom for 6 or 8 hours, the pressure maintained being thirty pounds. When the

vegetable matter has been thoroughly disintegrated, the envelopes enclosing fat globules destroyed or softened and the bones so changed in physical property that they may be crushed between the fingers, the whole mass is dropped through a twelve inch valve into a box-like receiver, one of which connects with four digesters.

After settling, the free water and grease are run off by means of drop pipes into separating vats—a series of catch basins—and the remaining sludge elevated by a bucket pump into filter cloths. The manner of performing this operation, which is really the essence of the process, is as follows :

A cloth is spread out on a low car about 5x6 feet. The turned-up edges of the cloth are supported by a wooden frame 6 inches deep and slightly smaller than the car, the ends of the cloth hanging down over it on all sides. After pumping this frame full of the sludge from the receiver the loose ends of the cloth are folded over the surface of the sludge, thus enclosing the latter on all sides. The frame is lifted off, a wooden slatted plate placed over the first layer, and the frame again on top of it. Another cloth is fitted in and pumped full, and so on, the operation being continued until the bags of sludge separated by the slatted plates have reached a height of about 5 feet on the car. The latter, which stands on a track, is then pushed under a screw press operated by steam power. These presses are supplied with 3 different gears, varying in power, which are applied consecutively, beginning with the least.

This operation forces down a smooth iron plate on top of the bags of sludge—just as a common copying press operates—the result being the expression through the cloths of water and grease. The liquid is carried by covered troughs in the floor to the separating vat before mentioned, where the clear grease rises to the surface and is skimmed off ready for shipment. The expressed water, colored a deep brown from the organic matter in solution, is run into the river.

The solid cake left in the presses, which still contains

about one-fourth of the water originally present in the garbage is charged into horizontal cylindrical dryers, heated by steam jackets and is kept constantly stirred up by a revolving reel. The operation of drying occupies about 3 hours for 2 tons of dry product. The dryers are exhausted of vapors by steam juts and the vapors subsequently condensed by cold water.

The dried "tankage" is screened ready for market and the coarse tailings consumed under the boilers. The tankage is used by manufacturers of fertilizers as a component of complete manures.

Hogel system: Rochester. Of this plant I have only a very slight knowledge and as I cannot speak from observation the merest outline must suffice for description.

The garbage is digested by steam under considerable pressure, the resulting sludge being pressed in a hydraulic press to separate most of the water and grease. A hot air dryer is used for drying the tankage which is then conveyed to a mixing pan where additions of phosphates and potash salts render it a complete fertilizer.

Class B.

Holthaus System: Bridgeport, Conn. The collection wagon empties its load directly into a dump car standing on an elevator. The car holds one ton and on reaching the upper floor is pushed out upon a track leading between two rows of digesting tanks. A broad funnel fitting into the man-hole at the top of the digester enables the complete contents of the car to be dumped into it at once.

The tank is made of plates of heavy cast iron bolted together, is six feet in diameter and charges five to seven tons raw garbage. Inside is a perforated steel cylinder head fitting snugly and supported from above by a thick piston passing out through the center of the top of the tank. Powerful hydraulic pressure exerted on the piston forces it down onto the contents of the tank.

Below the tank is closed by two 24-inch valves, one above the other and opening into the dryer. Two tanks connect with each dryer.

The charge of garbage is flooded with water, about fifty pounds oil of vitriol added and steam under thirty pounds pressure admitted for five or six hours. The perforated head is now forced down by setting the hydraulic pumps in motion and the grease and water pressed out of the material. These escape through perforated pipes running up the sides (the head is cut out to slide down over them), and also around the bottom. When all the liquid has been removed in this way, the large valves are opened and the charge forced into the dryer by again applying the pressure from above.

The dryer is a steam jacketed cylinder and fitted with a steam reel, fed and exhausted through a hollow shaft. The drying of a charge occupies about four hours.

The grease and water are led to a settling tank where they separate by gravity and the former is skimmed off by a mechanical device which in action is similar to drawing a stick across the surface. The grease goes to a second tank where air is continually sucked through it to the grate bars under the boilers. The water is led into a cast iron evaporating pan heated with lead coils, where it is concentrated until it has the consistency of liquid glue (about 50% solid matter) some of this being added to each charge of tankage in the drier. All the tankage is ground in a Denmead mill and screened for shipment. The dryers and evaporating pan are exhausted by a vacuum pump and all vapors are condensed with cold water.

Powter System: Pittsburg and Philadelphia. Wagons deliver the garbage into a pit from where a bucket elevator hoists it into a horizontal conveyor on the upper floor—thence into the digester. These are heated by steam jackets and connected below by an 8-inch valve with the dryer. Two digesters to each dryer. Five tons constitute a charge in the tanks, some water and sulphuric acid being added. The digestion is

carried on in the usual way with high pressure steam. After settling a couple of hours to permit the grease to rise to the surface, water is introduced below in order to raise the grease to the level of the draw-off cocks, through which it runs into a storage tank.

After removal of the grease, the valve below is thrown open, allowing the sludge to run into the dryer. Here is added phosphate rock and sulphate of potash and sufficient additional sulphuric acid to render the phosphoric acid in the rock "available" as plant food, or chemically stated, to convert the tricalcium into mono and dicalcium phosphate. The drying occupies from 8 to 16 hours. The resulting product is screened and sold as a complete fertilizer.

The dryers are exhausted by a vacuum pump, the vapors passed through cold water and then to the fires under the boilers.

Class C.

Simonin System: Providence and Cincinnati. The garbage is allowed to drain of superfluous water on a concrete floor and then loaded into carriages which are at once rolled into the horizontal extractors. These carriages support each a series of trays, made of coarse wire netting, enabling the garbage to be spread in layers of about six inches deep.

The extractors, which the loaded carriages almost completely fill, charge about 8 tons. When loaded the head is bolted over the opening, serving as an entrance for the carriages and the whole pumped full of naphtha. The naphtha is gradually vaporized by means of a closed steam coil in the bottom, carrying with it the water vapor from the garbage. The mixed vapor after passing off at the top is condensed in a worm cooled by a water jacket and the naphtha and water allowed to separate by gravity. The water is rejected and the naphtha used over continuously.

The evaporation in the extractor is continued until the lowest level of the charge of garbage has been reached, when

the liquid is drawn off and replaced by a fresh charge of naphtha. This is continued until the grease extraction is complete and all water is driven out of the garbage by the hot naphtha vapor passing through it.

The mixture of grease and naphtha, with some water, drawn from the bottom of the extractor, is settled, the water run off and the naphtha distilled in a separate still heated by steam. The residue is the grease.

The tankage is steamed, with live steam, in the extractor to drive out all adhering naphtha, and is then ground and screened ready for sale. (The Providence plant, which is the one here described, has been abandoned.)

Merz system: St. Louis, Minneapolis, Detroit and Buffalo. (Minneapolis plant destroyed by fire, Detroit and Buffalo made vital changes. The following describes the old Buffalo plant.)

On arrival at the works the load is hauled into a raised platform and backed up to a dump car standing on a track below. The car has a capacity of 1 ton, and when filled is pushed onto an elevator and taken to the upper floor, where it is dumped into receiving tanks.

These tanks have an opening below at a convenient level with the floor, and here the garbage is raked out and shoveled through 12-inch shafts to the dryers. These are horizontal, fitted with a solid reel and heated by steam jackets. Three thousand pounds constitute a charge, each machine having a capacity of 4 charges or 6 tons in 24 hours. The vapors from the dryers are carried by fans to the open air, there being no apparent necessity for avoiding odors.

After discharging from the dryers, a system of conveyors and elevators takes the garbage again to the upper floor and deposits it in the extractor. Ten tons of the dry material, equivalent to about 40 tons raw garbage, constitutes a charge.

The extractor is a simple iron tank with perforated false bottom on which the charge rests. It is heated by a steam

coil below. Naphtha is pumped in to a level with the top of the charge and heated, maintaining a pressure of about 10 pounds, controlled by a valve blowing off into a condenser above. The boiling is continued about 4 hours, after which the naphtha and grease with a little remaining water is run through a continuous separator. First the water is removed by gravity, then the naphtha by superheated steam, the grease remaining. The tankage is freed from adhering naphtha by open steaming, ground and screened. All naphtha vapors pass through one condenser and are recovered for further use.

Merz Improved: Buffalo. The change made is that digestion by steam precedes the drying.

The garbage is dumped directly into digesters fitted with a perforated false bottom on which the charge rests. Steam is introduced at the top under pressure, exhausting through a small vent below the false bottom. The accumulation of water and actual cooking is thus avoided. Five to six tons is a charge and 8 hours is consumed by this operation.

The grease and water drawn off below are separated by gravity and the water evaporated off in a vacuum pan. The solid residue thus obtained is added in small quantities to the dryers. From the digesters the garbage goes to the dryers and thence to the extractors—the process being identical with that last described. The modification introduced in Detroit is of a similar nature, steam digestion preceding drying and extracting as by the old Merz system.

The grade of the tankage produced from garbage varies with the season and the manner in which it is obtained. The following figures, however, probably cover the extremes:

Nitrogen	2.5 to 3.5%
Phosphoric acid	1.5 to 4.0%
Potash	1.0 to 1.5%

W. E. Garrigues.

THE DUQUESNE CHEMICAL LABORATORY, PITTSBURG, PA.

DISCUSSION.

THE CHAIRMAN. Gentlemen, are there any questions you would like answered by Mr. Garrigues?

MR. J. O. HANDY. What is the commercial status of garbage companies in other cities; do they pay the city for the garbage or does the city pay them for disposing of it?

MR. W. E. GARRIGUES. All receive a bonus, even the proprietors of some of the processes do not claim that they will pay for themselves. This is independent of the cost of collection.

PROF. FESSENDEN. What can the grease obtained from a ton of garbage be sold for?

MR. GARRIGUES. At the present low price of grease and estimating the percentage of grease at 3%, the grease from a ton of garbage would be worth $1.20, 400 pounds of tankage would be worth $1.00 or a total value of $2.20 per ton, treated.

PROF. FESSENDEN. I wish to make a comparison with an English method in which garbage is used as fuel. It has been stated that the fuel value of garbage is about 50 cents per ton. This of course is not profit, as the expense of the special arrangements for burning the garbage is greater than for coal.

DR. JOHNSON. Is garbage sorted?

MR. GARRIGUES. The regulations in different cities vary, but all require separation of ashes and paper from garbage proper.

THE CHAIRMAN. What is the grease used for?

MR. GARRIGUES. For making candles mainly, it is nearly all sent to England, though some is used in Cincinnati. After separation of the glycerine, the grease is distilled by superheated steam previous to pressing out the fluid oil. The residue is candle stock. The grease cannot be used in making any but the coarsest grades of soap.

MR. JNO. A. MCCONNELL. In the acid systems does not the acid eat the tanks?

MR. GARRIGUES. Yes, that is an expense that must be allowed for.

MR. HANDY. Have there been troubles in other places than Pittsburg in regard to odors?

MR. GARRIGUES. Yes, in several places the works have been run out of town. The best plan is to have your plant where there is no one to object to the odor, as the imagination would supply an odor even if there were none.

DR. K. F. STAHL. Have not the Pittsburg Garbage Co. found out how to avoid trouble from the odors?

MR. HANDY. By leading gases through hot pipes with addition of a little steam the odor can be entirely destroyed.

MR. GARRIGUES. If gases are led through cold water and sufficient water is used, I am satisfied that the odors will be completely condensed.

THE CHAIRMAN. Are not the pipes attacked?

MR. HANDY. Yes. A set recently taken out seemed to be carbonized so that the metal resembled cast iron.

The meeting adjourned at 10 P. M.

A. G. MCKENNA,
Secretary C. S.

Engineers' Society of Western Pennsylvania.

THIS SOCIETY DOES NOT HOLD ITSELF RESPONSIBLE FOR THE OPINIONS OF ITS MEMBERS.

Pittsburg, Pa., December 16, 1896.

The regular monthly meeting of the Engineers' Society of Western Pennsylvania, was held in the Lecture Hall of the Society, 410 Penn Avenue, Pittsburg, Tuesday evening, Dec. 16, Mr. Wilkins in the chair. The meeting was called to order at 8:30, thirty-two members and visitors being present.

The minutes of the last meeting were read and approved.

Reporting for the Board of Direction, the Secretary read the names of three applicants for membership, which were approved by the Board and will be voted on at the next meeting.

The election of new members being in order, the names of John N. Chester, John M. Cunningham, David W. McNaugher and Orville C. Skinner were brought up for ballot. Each one receiving twenty-seven votes they were declared duly elected.

The President remarked that there were two committees appointed, one to prepare a memorial on the death of Mr. M. J. Becker, and the other on the death of Mr. Hepburn Walker, and asked if these committees were now ready to report.

Mr. George S. Davison presented the following report on the death of Mr. Hepburn Walker :

MEMOIR ON THE DEATH OF HEPBURN WALKER.

Hepburn Walker was born in Allegheny City on October 12, 1853. After finishing his education he was employed by the Allegheny Gas Company until the year 1875, when he became a member of the firm of Harbison & Walker of this

city, with which firm he was identified until his death, which occurred on the ninth day of October, 1895.

Mr. Johnson stated that the committee on the death of Mr. Becker was not yet ready to report.

The President also called the attention of the members to the death of Mr. G. W. G. Ferris, and stated that it would be in order to appoint another committee to prepare resolutions on his death.

It was moved and seconded that such a committee be appointed. Carried. The President appointed the following persons on this committee: Gustave Kaufman and D. W. McNaugher.

Mr. S. H. Stupakoff here read the paper of the evening entitled: "Railroad Signaling and Interlocking."

RAILROAD SIGNALING AND INTERLOCKING.

The network of railroads all over the world, and especially in all civilized countries has become more and more dense within the latter half of our century. Traffic and freight shipments on the same have constantly and enormously increased, and the dangers connected with railroad service have necessarily increased in a like ratio. The management and safe conveyance of passengers and goods has become more and more complicated, and consequently safeguards against accidents became an absolute necessity. Their study, their development and their construction created a new branch in engineering which falls exclusively in the scope of the signal engineer.

Among the many railroad safety appliances which have been introduced within the last fifty or sixty years, signaling and interlocking provides for the safety of the road itself. In following the rule, that "two bodies cannot at the same time occupy the same space" and providing the means therefor, that they should never be tempted to do so, the whole problem of signaling and interlocking on railroads is solved. All such safety appliances serve therefore for the purpose to prevent

trains, cars, engines, vehicles, or other obstacles to use or occupy the same piece or section of a railroad track at the same time.

The roadway of a railroad must be naturally divided into two main parts; namely: the straight track and crossings, yards or stations. Accordingly, the signaling system is divided likewise into two corresponding divisions, which are called "Block Signaling and Interlocking Systems."

The straight track, which is that part of the road lying between two stations, is, according to its length, or its traffic or both, subdivided into a number of shorter sections, which are under ordinary circumstances from one-half a mile to one mile long, but sometimes as much as four miles long. Each of these parts form a section, or a "block" of the whole block system.

Yards, in which various tracks cross each other, and where the shifting movements are controlled from a single central point, with a view of regulating such movements to prevent conflicting train movements, and consequently to prevent casual accidents, come under the head of interlocking systems.

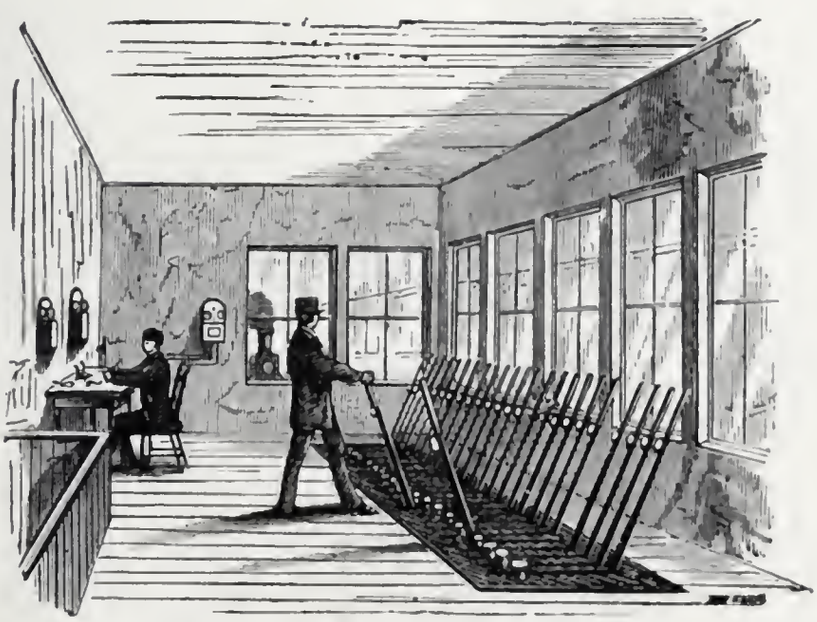


Fig. 1. Interior of Signal Tower.

The signals themselves can be divided into the two main groups of the visible and audible signals. Visible signals are

given by flags, discs, arms, lamps and lanterns; audible signals by bells, gongs, whistles and detonating torpedos.

Visible signals again, can be subdivided into the secondary groups of position signals and color signals; and further into day and night signals.

Audible signals can be considered as auxiliary signals only.

Of all these, the position signals deserve undoubtedly the preference, and especially such a form, which gives the same sign by day and night. And again, among all the various forms and shapes of signals, those which give the most distinct, and the most unmistakable sign, are best suited for the purpose.

The semaphore signal is best adapted for giving a distinct visible sign, and it is therefore almost universally applied for this purpose. Only for special reasons it is sometimes replaced by discs, banners, shields, star and other shapes, and mainly in such cases only, where the operating power at disposal recommends a deviation from the semaphore arm.

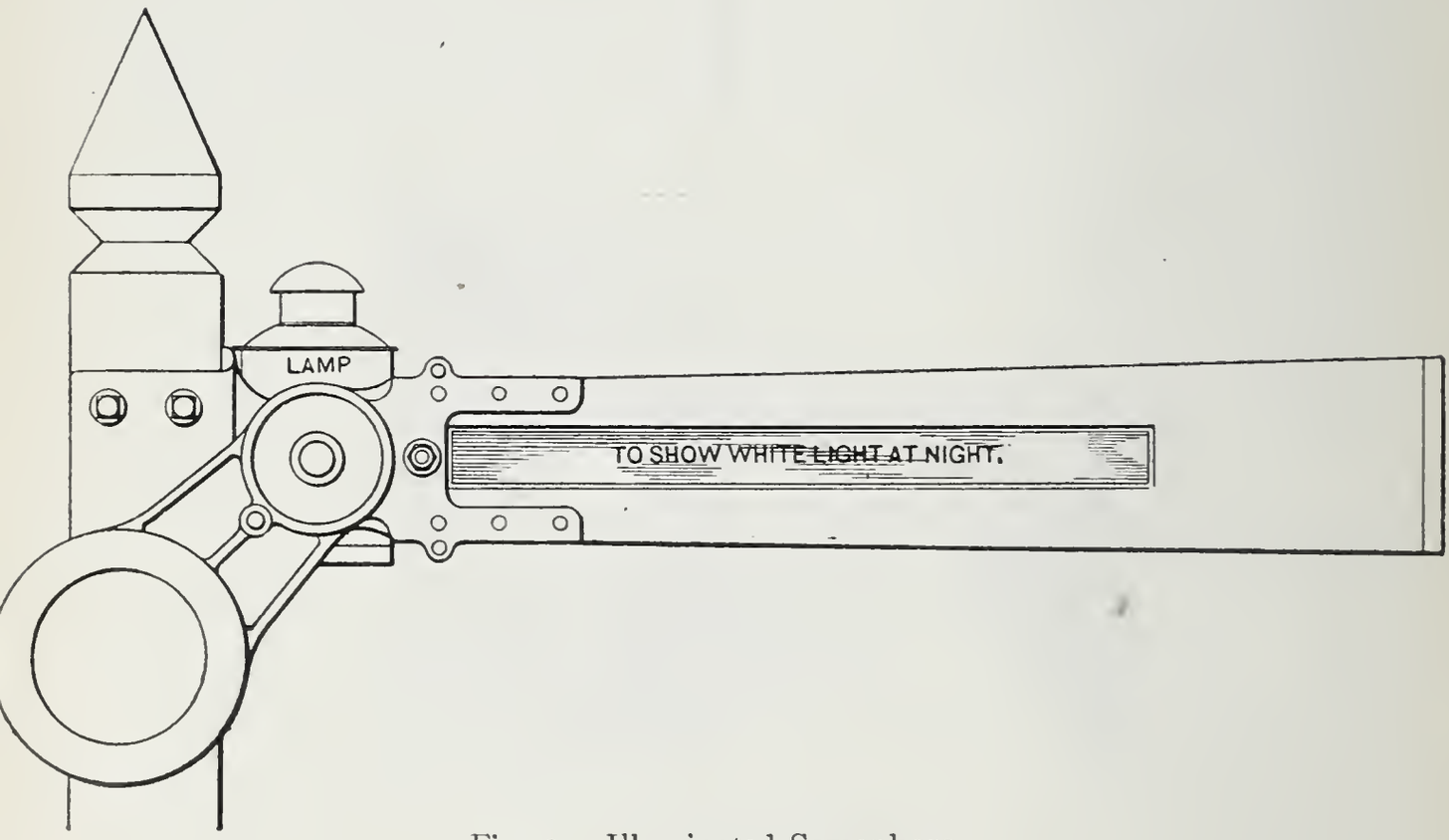


Fig. 2. Illuminated Semaphore.

As night signal, the illuminated semaphore arm is the best, when a sufficient volume of light can be applied to the same. The next best, is the system in use at an eastern road, which uses a series of lamps to indicate either the horizontal or the inclined position of the semaphore arm, which serves as day signal.

The horizontal position of the semaphore arm has been almost universally adopted as a danger signal, and its inclined, or vertical position as a safety or clear signal.

There are two different kinds of signals used on nearly all roads in this country, the function of one of these is to give a "stop" and that of the other to give a "caution signal."

Fig. 4. Stop Signal.

Fig. 5. Caution Signal.

When the stop signal indicates danger, the engineer of an approaching train is compelled to bring his engine to a standstill in front of it, while the caution signal in its horizontal position compels him merely to get his engine under control and prepare for an immediate stop when necessary.

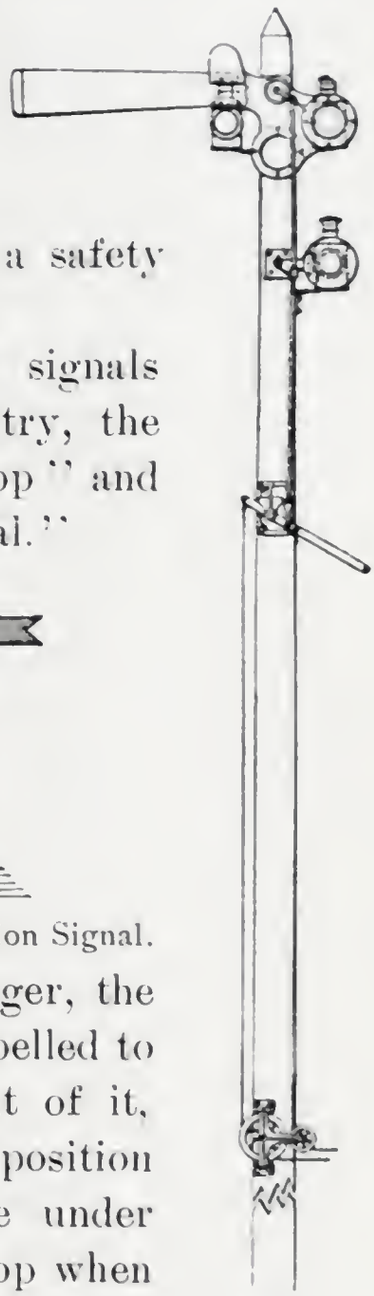


Fig. 3.

Stop signals are generally called "home" and caution signals "distant signals."

In general practice it is customary to combine color with position signals. For this purpose positive stop or home signals are painted usually vermillion red for day service and

show in their danger position for night service a red light. Caution or distant signals are painted green for day service, and show correspondingly for night service a green light. A white light at night indicates in all cases a clear signal.

Your patience and the limited time at my disposal do not permit me to give you to-night a detailed description of all the various forms of signals and of the various mechanisms in use to operate the same. Therefore, I will give you only a short description of the semaphore signal only, which is the one I have just now alluded to as the one which has been universally adopted as the standard among railroad men.

The semaphore signal consists of an arm of about five feet in length by seven to nine inches in width, which is pivoted at a place near the center of a metallic frame work to which it is secured by bolts, and it is journaled in a bearing on a vertical post at a suitable height above the level of the railroad track. This metallic frame work, known as the semaphore casting, is provided opposite to the arm, with a ring or spectacle which contains mostly a colored glass. Depended upon the relative position of the signal, the light of a lantern shines at night through this glass, or it appears without it—white.

The semaphore arm or blade is always made of strong and light material, mostly ash, or sometimes of light sheet metal, while the semaphore casting is sufficiently weighted, to bring this arm constantly in a horizontal position, when swinging loosely on its pivot, or center of revolution. A wire or a rod connects the semaphore casting, or the semaphore arm respectively, with an operating lever or mechanism, by means of which the position of the blade can be changed from the horizontal to an inclined or vertical position, or vice versa. The object of counterweighting the blade is to return the same in all instances to the horizontal or danger position, should some of the operating parts fail or break.

The simplest mode of operating such a signal is by attaching to the semaphore casting, on the side of the blade a rope,

wire, rod or chain, which may be provided at its lower end with a ring, and pulling therewith the blade downward to its clear or safety position. The ring can be slipped over a hook or nail and thus hold the arm until it is restored to its horizontal or danger position. This arrangement is oftentimes used in connection with station signals.

It is obvious that this arrangement does not permit the operator to be stationed at a great distance from the signal itself. Where this is unavoidable, there is either one wire connected to each side of the semaphore casting on opposite sides of its center of revolution, or a stiff rod or pipe line leads from the semaphore to an operating lever, which in some instances is located at a distance of more than two thousand feet from the signal. A reversal of such a lever will impart unto the signal a corresponding upward or downward motion and place it either to the danger or clear position, as the case may require.

These simple mechanisms work of course admirably well, when properly attended to, and never give rise to trouble if kept in good working order ; providing the signals are observed by the engineers of moving trains or locomotives. But after all, the responsibility for the safe conveyance of passengers, goods and rolling stock rests in the hands of the engineer, and unless he is thoroughly trustworthy, aware of the duties imposed upon him, wide awake in cases of emergency and obedient to the rules prescribed by the system of signaling, which must be strictly observed by him, the best systems of signaling may become a failure in his hands. In such cases, however, where the working of the respective systems requires the services of a number of employes, this responsibility rests upon the trustworthiness and reliability of every single one of them, and the safety of a railroad diminishes therefore in a like ratio. Therefore, the aim of railroad managements has been to adopt such systems which require the employment of the least possible number of employes for their safe working.

The ideal system for this purpose is naturally the one which stops a train automatically, whenever it enters a part of a road which may bring it to danger. But we are not yet quite far enough advanced to provide our locomotives with reliable appliances which will throttle their steam valves automatically, without the aid of the engineer, before they reach a spot which may bring them to disaster; though, we have an appliance which works in connection with the air brake, and automatically stops a train when it passes a signal in the danger position. This is certainly a step in the right direction; but the device being a new one, the conservative managements of our railroads could so far be induced to give it a few test trials only. Therefore we trust in this respect still to the reliability of our engineer, while in other respects we have practically perfect automatic signaling safety appliances, which, if universally introduced, should bring the stock of accident insurance companies considerable above par.

To illustrate the usefulness and the necessity of a signal let us represent the simplest case:

"A main track with an ordinary siding." An engineer moving toward such a spot should have positive knowledge of the condition of the track in this place before he reaches the same, and he should therefore be informed, while he is still at some distance from it, whether the switch is set for the main track or for the siding; or to speak in the language of a railroader, whether it is closed or open. A train which arrived at this switch previously, may have left some cars on the siding, and in moving out may have left it open, or the same train may still make some shifting movements while the second one approaches. It is evident, that in such a case, without previous warning, the second train may either run into the switch or come into collision with the cars left thereon, or it may have some encounter with some part of the first train, which is still in reach. To avoid accidents of this character the switch stands either in direct or indirect con-

nection with one or more signals. If two signals are used, one of them stands always in close proximity—generally fifty feet from the switch, while the other one, according to circumstances may be located at times as far as fifteen hundred to two thousand feet away from it. The first mentioned one is the home and the second one the distant signal. These signals normally show a clear track and occupy consequently their safety position. The mechanism operating the same is arranged in such a way that it will first reverse the position of these signals and hence place them at danger, before the switch itself can be opened or reversed, and they cannot be replaced to their normal position as long as the switch remains open. Additional safeguards control frequently the position of these signals and keep them at danger, as long as obstructions lie within reach of the fouling point at a switch. An engineer coming within sight of such a distant signal, which is held in a danger position, knows that the track ahead of him is obstructed, that he has to get his engine under control and that he has to prepare himself to stop in front of the home signal, which he knows he will also find at danger.

This example gives sufficient proof that it is of the utmost importance in signaling, that a signal shall never show or assume a safety position, as long as that particular part which it controls is in some way blocked or dangerously obstructed. To dangers of this class belong, besides the before mentioned misplaced or open switches, broken rails and trains or parts of trains in a block to be entered.

Now let us imagine a block with a sharp curve, the condition of which cannot be overlooked over its entire extent, or from one end of the block to the other. We have numerous places of this description in our immediate neighborhood, in and around Pittsburg In such cases we are at a loss how to provide absolute safety to trains rapidly following each other, if we should be compelled to depend solely upon the aid of mechanically and manually operated block signals; and in order

to keep up an uninterrupted and large traffic we employ other means to indicate positively the condition of the track.

The best and only reliable means for this purpose is the application of an electric rail circuit, in combination with electrically controlled signals. Since its introduction it has been always successfully used in connection with all automatic and semi-automatic electric, hydraulic and pneumatic signals.

The purpose of this electric control is to prevent that a signal should remain in its safety position, whenever its relative block section is occupied, or, when for other reasons it is unsafe for a train to enter the same; at the same time it is to cause the safety position of a signal to be changed automatically to the danger position, as soon as irregularities occur on that particular section of the road which it controls.

Railroads in this country follow two primary rules in block signaling. One of these prescribes, that the normal position of all block signals shall indicate "safety," and the other one demands the contrary, that they shall show normally all "danger." I may add, that the latter is universally adopted for such signals in Europe.

Though it is not my intention to discuss in this place the pro and con of the various systems and appliances, I cannot omit to remark, that the normal danger position of all automatic signals is disposed to place the engineer in a sensation of constant uncertainty, which would naturally hinder the rapid transit on busy lines. Besides this, it is impossible to submit the signals in such a position to a quick and superficial inspection, since it is not possible to determine from their normal position, whether they are in working order or not; and furthermore, there are no good reasons, why a railroad track should be blocked by danger signals, when there is nothing in the road to permit moving trains to continue their runs unmolested.

There is a piece of track near Elizabeth, at the Jersey Central road, where the signals can be seen for miles ahead of

the train. Imagine yourself riding over this road at the rate of sixty miles an hour, which is the usual speed, and imagine numerous red lights of danger signals glaring into your face at a dark night, with exception of the one nearest to you, which gives a white light, indicating safety and a clear track for the next block in front of you, which you will have passed within the next half minute. It would scare the most courageous and the nerviest, and it would make the most daring engineer feel timid in expectation of a crash or a collision. He would see continuously the pile of debris, broken-up cars and overturned engines in front of him, he would hear the cries and the moaning of the injured and dying, between the search lights of the relief corps and the red danger prophets in front of him.

This would be the state of things when a system is used, whereby all signals occupy normally the danger position; but luckily, it is not, and the engineer whom we entrust with our lives sees for miles ahead of him a clear track if no obstructions are on his road. A single green light which he may find occasionally, and see miles ahead of him before he reaches it, will give ample warning and sufficient time to get his engine under control in order to stop in front of the red signal which he will meet with at the beginning of the following section.

If the railroad track is unobstructed and free, the signals belonging to and governing such a piece of track should naturally and for the sake of consistency indicate a clear track also. Blocked, however, and protected by danger signals should be only such sections or portions of track, which should not be entered unless the necessary permission to do so is given by a clear signal. Such cases, however, are mostly met with at terminals, yards, stations, junctions, crossings, sidings, drawbridges and tunnels only.

Since it is not possible to enter here into a detailed description of every one of the various block signaling systems, I will limit myself to explain to you a few devices used in connection with the electro-pneumatic system, giving to you at the

same time a description of their various functions and their their manipulation.

As mentioned before, the portion of a railroad track lying between two stations or points of interlocking is subdivided into a number of sections or blocks. Each block is provided at its beginning with a signal post which carries as a rule two semaphore arms. The arms point generally to the right (with exception of a few left running roads). The upper one of these two signals is the home and the lower one the distant signal. The home signal indicates the condition of the block immediately ahead of it, and the distant signal indicates the same of the second block ahead. Both signal arms are normally lowered and point therefore to safety, which gives permission to approaching trains to continue.

Suppose the whole road to be without all obstructions, a moving train will find all signals at safety ahead of it. But as soon as the first pair of wheels enters the first block the home signal controlling the same will assume the danger position carrying with it the distant signal on the same post. The

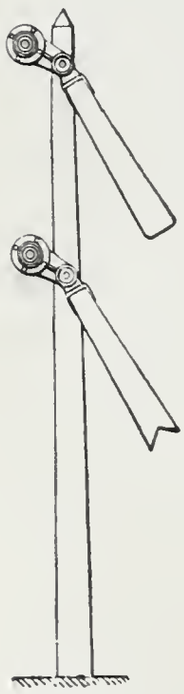


Fig. 7.
Home and Distant Signal at Safety.

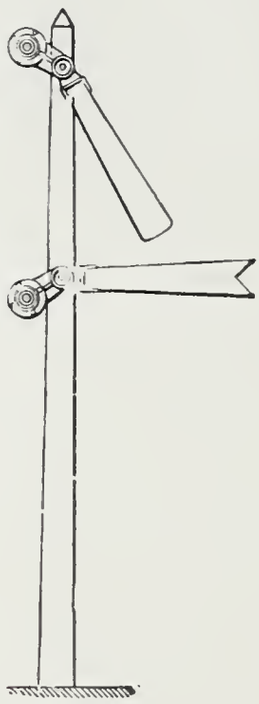


Fig. 8.
Home Signal at Safety. Distant Signal at Caution.

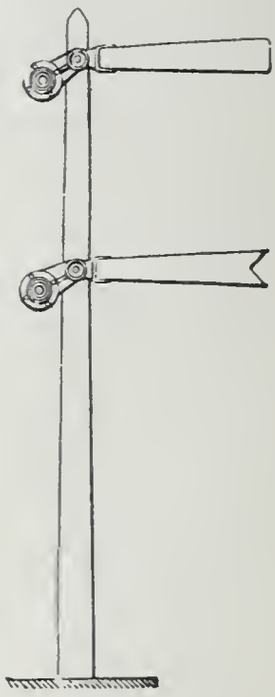


Fig. 9.
Home Signal at Danger. Distant Signal at Caution.

home signal will remain in this position until the last pair of wheels of the train has left the block when it will resume its normal or safety position; while the distant signal will not return to normal until the last pair of wheels of the train have left the second block ahead. The working of all signals on the whole section takes place in the same manner, and all signals will have resumed their normal position after the last pair of wheels of the train have left the entire section. (See diagrams 7, 8, 9, 10 of Fig. 10.)

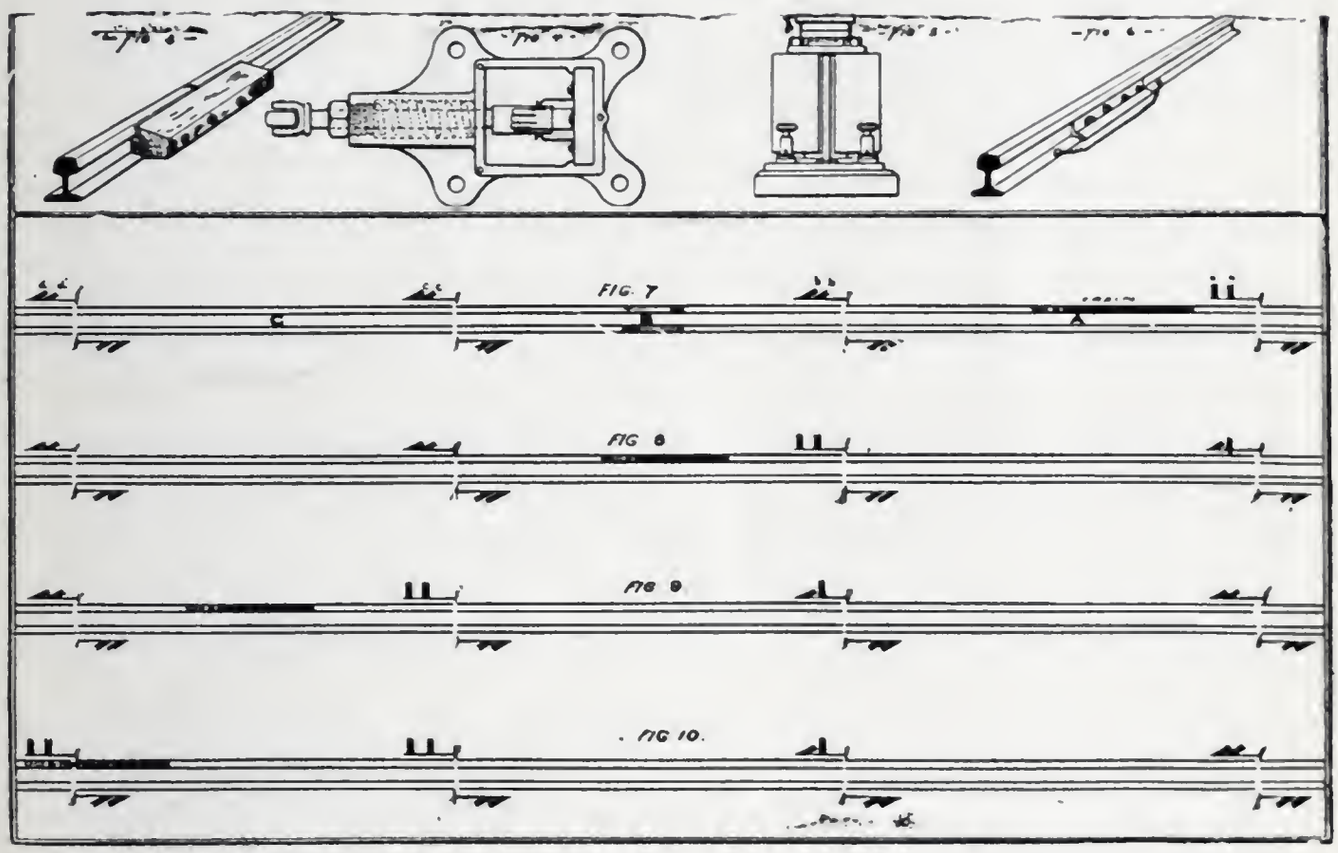


Fig. 10.

In causing the signals to assume the danger position, the train is always protected from the rear by two distant and one home signal, and a following train has always positive knowledge of the condition of two blocks ahead. For the two sections ahead are free if both signals are clear; the next lying block is occupied if both signals are found at danger, and the second section ahead is occupied if the distant signal indicates caution.

If the system is worked with "normal danger signals" the working will be as follows: All semaphore arms point horizontally and the home signal shows at night a red, while the distant signals show a green light when no trains are running. Approaching trains cause a reversal of the signals before they reach the same, at a distance of about a thousand feet more or less. The engineer can therefore see the movement of the signal next ahead of him, provided the track is straight and convince himself if it is in good working order. He will have to stop his train if the expected reversal of the home signal does not take place and he will have to bring his engine under control if the distant signal remains at caution.

I have pointed out to you why the normal safety signals deserve the preference, and at least in *electro-pneumatic block signaling* the "normal danger signals" are not favored and not used in this country.

The working of this system is accomplished entirely by making use of potential energies. Compressed air is used to move the signal arms to, and keep them in a safety position. Electric currents are employed to control the movements of the signals and weights bring the same back to their danger position.

The compressed air is conveyed to the respective apparatuses from a central point by means of pipes which are suitably arranged alongside of the tracks of the railroad. Such central stations are from ten to twenty miles apart from each other and generally located at such points where steam power is used for other purposes. Each of these power stations is equipped with two air compresses, of which one serves as a reserve, since an interruption in the continuous service of the system is to be absolutely avoided, and therefore provisions against cases of emergency are made from the beginning. The air pressure is regulated by valves and kept constantly at from sixty to eighty pounds. The air compressors are self-governing; they increase their speed automatically when the pressure

in the system drops, and likewise they reduce their speed when the pressure rises or when it arrives at its upper limit.

The main pipe line is two inches in diameter and their branch-offs three-fourths inches. They are preferably imbedded in pitch in closed trunking or terra-cotta pipe underground, but they have also been used successfully mounted several feet above the ground on stakes or posts.

Expansion joints are inserted at suitable intervals to compensate for an eventual expansion or contraction caused by the difference of temperature.

The electric current is produced either by galvanic batteries or by dynamos, and in the latter case transmitted to the instrument by means of storage batteries.

The electric rail circuit, or the track circuit which I have mentioned above, is independent from all other electric circuits used in connection with the system. It consists of one or more cells of gravity battery, or its equivalent, the rails as conductors and a relay. (See 5, Fig. 10.) All rails belonging to the same circuit are electrically connected to each other by galvanized iron wires, which are known as track wires (shown in upper right hand corner of figure 10). Without these wires it would be impossible to conduct the slight current through the large number of rusty bolts and splices from one end of the block to the other. The rail ends between the blocks are insulated from each other by the insertion of fibre and by the use of either oak or fibre covered splices (shown in upper left hand corner of figure 10). The end rails of each section are connected by wires electrically to the said battery and the rails at the opposite end of the section in the same manner to the terminals of the relay magnet. We have consequently a closed circuit; and the electric current flows from the positive pole of the battery through one set of rails to the other end of the section, thence through the magnet of the relay and back through the other set of rails to the negative pole of the battery. The current flowing through the relay magnet excites the same and

attracts an armature pivoted near its pole ends. This causes the closing of contact points which complete another electric circuit which controls directly the operation of the signal mechanism.

The signal mechanism consists of a cylinder and piston, an electrically operated double valve with air chamber and an electro-magnet, with armature and armature valve stem. The valve chamber stands in direct connection with the compressed air line, and the air pressure resting upon one side of the piston, when the inlet valve is opened, presses and holds the same against the opposite end of the cylinder. The inlet valve is opened and pressed from its seat by means of the stem of the attracted armature. This armature stem closes at the same time with its lower end the exhaust of the cylinder. The armature of this magnet is attracted by a local current, which flows from a somewhat stronger battery than the one described in connection with the rail circuit, through the closed contact points of the relay, and from there through the windings of the signal magnet back to the battery.

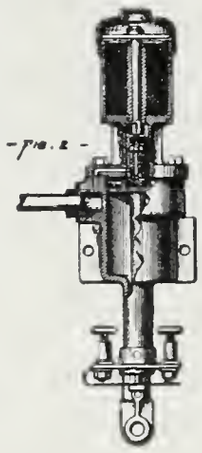


Fig. 16. Electro Pneumatic Signal Cylinder.

The piston rod being directly, or by insertion of a balance lever and connecting rod, indirectly connected with the signal arm, holds it in this condition downward until either the flow of current or the pressure upon the piston is interrupted.

The weighted semaphore casting or a counterweight on the raised arm of the balance lever, or a spring brings the semaphore in this case to its horizontal or danger position.

This takes place in all cases if any of the devices used break or fail to act properly, if a break in the electric connections, in the air line, or in the rails occurs, or if any of the mechanical parts get broken, if the electric current or the pressure gives out and if a pair of wheels with their axle cross any place of the two rails forming the track circuit.

Our signal indicates danger therefore whenever the two rails are crossed by some electric conductor and it will remain in such a position until such an obstruction is removed.

The track battery acting upon the relay is in this case short circuited; which means that the current has found a shorter way than the one through the total length of the rails and the windings of the relay magnet, to return from the positive pole of the battery to its negative pole.

A pair of car wheels with their heavy axle offer of course less resistance to the current than a mile or two of rail with its number of track wires and additional copper wire of smaller diameter in the windings of the relay magnet.

Thus we have seen, that without human agency these signals will indicate in all cases not only the exact condition of the track, but by assuming automatically a danger position in cases of derangement, they will also show that some of their working parts or their sources of power or control need repair and overhauling, which is promptly reported by every passing engineer.

After the paper was read the President stated that owing to the lateness of the hour, and the fact that some other business was to be transacted, he thought that the discussion had better be deferred until the next meeting.

Mr. Bole, Chairman of the Nominating Committee, read

the names of those nominated to hold office during the ensuing year. They are as follows:

For President to serve one year, Emil Swensson.

For Vice-President to serve two years, Harry J. Lewis.

For Directors to serve two years, H. H. McClintic and James M. Camp.

For Secretary to serve one year, R. A. Fessenden.

For Treasurer to serve one year, A. E. Frost.

For members of the auditing committee the President appointed H. H. McClintic and Selwyn M. Taylor.

On behalf of the committee appointed to investigate Mr. Arthur Kirk's pavement Mr. Diescher stated that owing to Mr. Kirk's absence in Harrisburg, and on account of his wish to be present when the report was rendered, the same would be deferred until such time as Mr. Kirk could be here.

Mr. Swensson moved that the Reception Committee be given instructions and power to act as they see fit, as regards arranging for a banquet in the near future. Carried.

Adjourned.

DANIEL CARHART,
Secretary.

MEETING OF THE CHEMICAL SECTION.

The regular monthly meeting of the Chemical Section of the Engineers' Society of Western Pennsylvania, was held in the Lecture Room of the Society, 410 Penn Avenue, Pittsburg, Thursday evening, December 17, 1896.

President J. M. Camp in the chair. The meeting was called to order at 8:30. Seventeen chemists were present.

The minutes of the last meeting were read and approved.

Dr. F. C. Philips, for the Committee on Methods, made a final report, showing the work done by the Committee during the years 1895 and 1896, and asked that the Committee be discharged. On motion of Mr. Unger the Society discharged the Committee from further service.

The Secretary announced the election of Mr. Skinner and the application of Mr. Mohr and Mr. Marshall to membership in the Chemical Section.

The Committee on nominations for the ensuing year reported the following list of officers:

Chairman, Mr. W. E. Garrigues; Vice-Chairman, Dr. K. F. Stahl; Secretary, Mr. A. G. McKenna; Directors, Mr. F. Strunz and Mr. H. S. Menough.

Mr. R. B. Carnahan, Jr., read the paper of the evening entitled: "Oxide in Iron and Steel."

OXIDE IN IRON, STEEL, ETC.

BY THEO. TONNELÉ AND R. B. CARNAHAN, JR.

The investigations of which this paper is a record were made for the purpose of simplifying, if possible, the determination of "Oxide of Iron" in iron and steel.

There are four well-known methods in use by different chemists:

I. Ledebur's Method.—The sample is ignited in a stream of Hydrogen Gas. The water formed is caught in Phosphoric Anhydride, weighed, and from it the oxygen calculated.

II. Volatilization of the iron in a stream of Chlorine gas and weighing of the residual oxide.

III. Solution of the iron in Bromine and water, with the subsequent weighing of residual oxide.

IV. Solution of the iron in Iodine and water, with subsequent weighing of residual oxide.

The first two methods give comparative results, and in all probability are fairly accurate, if properly executed. Such methods, however, while of great value for theoretical investigations, are too difficult of manipulation for running routine laboratory work. Of the last two methods, both of which are quite simple, the Iodine method is generally considered the most accurate, for the reason that the action of Iodine is milder than Bromine. In the list of determinations which shall follow later, there are a considerable number of results obtained by the Iodine method, and a few by the Bromine method. The first two methods spoken of were not used. Most of the results were obtained by the use of other methods, the aim being to find out the comparative effect of various solvents.

The following is a list and description of the samples employed in the investigations :

	OPEN HEARTH STEEL.			BESSEMER STEEL.		BESSEMER STEEL UNRECARBONIZED.
	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.	No. 6.
Silicon	.010	.013	.010	.010	.010	
Sulphur	.039	.031	.030	.065	.062	.06
Phosphorus	.095	.046	.056	.094	.096	.10
Carbon	.14	.15	.105	.060	.090	.03
Manganese	.43	.39	.280	.370	.410	None

No. 7.—Same Steel Carburized (I.)

No. 8.—Same Steel Carburized (II.)

No. 9.—Bessemer Steel—Unrecarburized.

No. 10.—Bessemer Steel.

Carbon	.08
Manganese	.40

No. 11.—Bessemer Steel.

Sulphur	.042
Carbon	.11
Phosphorus	.105
Manganese	.47

No. 12.—Tool Steel.

Silicon	.10
Sulphur	.01
Phosphorus	.04
Carbon	.90
Manganese	.35

No. 13.—Swedish Charcoal Iron.

Silicon	.016
Sulphur	.006
Phosphorus	.020

No. 14.—Chautaugay Charcoal Iron.

Silicon	.132
Sulphur	.011
Phosphorus	.025

No. 15.—Special Muck Iron.

Silicon	.090
Sulphur	.015
Phosphorus	.010

No. 16.—Special Muck Iron.

Silicon	.170
Sulphur	.013
Phosphorus	.018

I.—

II.—

III.—

IV.—

V.—

No. 17.—Same as No. 16, Repiled and Rerolled.

No. 18.—Special Muck Iron.

No. 19.—Same as No. 18, Repiled and Rerolled.

No. 20.—Bessemer Steel.

Silicon	.01
Sulphur	.06
Phosphorus	.09
Carbon	.10
Manganese	.52

No. 21.—Bessemer Steel.

Carbon	.08
Manganese	.40

No. 22.—Bessemer Steel.

Carbon	.08
Manganese	.42

No. 23.—Muck Iron.

Silicon	.10
Sulphur	.015
Phosphorus	.010

Before giving a list and description of the methods used, a few points common to all methods are in place.

The temperature at which solution and filtration were made was (unless otherwise stated) at about 15 degrees C., the temperature of ordinary tap water. The washing of the oxide residue was performed with cold water containing no acid whatever, unless otherwise stated. It was found by several experiments that the error due to incomplete washing out of the ferric chloride, etc., from the filter paper did not exceed .02 per cent. and was sometimes less. In nearly all analyses, 2 grams of the sample were used. The silica present in the oxide residue was subtracted or expelled by hydrofluoric acid. In steels, however, the silica was disregarded. Filter papers practically ashless, were used.

Method I.—2 gm. metal are dissolved in 18 gm. iodine, and a few c.c. of boiled water. Residue filtered off, washed, burned and weighed.

II. Dissolved in 50 c.c. water and 3 c.c. bromine. Filtered, washed, burned and weighed.

III. Dissolved in saturated solution (100 c.c.) of copper and potassium chloride containing 1 per cent. hydrochloric acid. Residue washed with cold water, containing 1 per cent. hydrochloric acid. Washed with pure water, burned and weighed.

IV. Same as III except ½ per cent. instead of 1 per cent. hydrochloric acid.

V. Dissolved in 100 c.c. of a 10 per cent. solution of copper and potassium chloride, containing 3 c.c. pure bromine. Washed and weighed.

VI. Dissolved in 100 c.c. of a 10 per cent. solution of copper sulphate (neutral), containing 3 c.c. bromine. Washed, weighed.

VII. Dissolved in saturated solution of copper and potassium chloride with 1 per cent. HCl, and let stand 15 minutes at 60 degrees C. Washed with 1 per cent. HCl wash.

RESULTS.

Method I.—No.	1.	.10	per cent.	
No.	4.	.50	"	
No.	6.	.30–(33)	"	
No.	11.	.70	"	
No.	20.	.25	"	
No.	21.	1.45	"	stood over night.
		1.20	"	stood 24 hours.
		1.10	"	stood 48 hours.
No.	22.	1.10	"	stood over night.
		.85	"	stood 24 hours.
		.70	"	stood 48 hours.
Method II.—No.	1.	1.37	"	filtered immed'ly
No.	1.	.15	"	stood 2 hours.
No.	1.	1.00	"	stood few min.
No.	6.	.18	"	

Method III.—	No.	1.	.14	per cent.
	No.	4.	.95	"
	No.	5.	1.00	"
	No.	13.	.33	"
	No.	14.	.75	"
	No.	15.	2.67	"
	No.	16– I.	1.13	"
	No.	16–II.	.75	"
Method IV.—	No.	15.	1.04	"
	No.	16-III.	.59	"
	No.	16-IV.	.83	"
	No.	16- V.	.51	"
	No.	23.	1.18	"
	No.	23.	1.30	"
Method V.—	No.	1.	.77	"
	No.	1.	.80	"
	No.	1.	.83	"
	No.	1.	.35	"
	No.	2.	1.28	"
	No.	3.	.88	"
	No.	4.	.43	"
	No.	6.	.31	"
	No.	6.	.22	"
	No.	7.	.45	"
	No.	8.	.52	"
	No.	9.	.32	"
	No.	10.	.80	"
	No.	11.	.82	"
	No.	12.	.50	" stood 2 days.
	No.	12.	4.21	"
	No.	13.	.36	"
	No.	14.	1.32	"
	No.	14.	1.48	"
	No.	16–II.	2.87	"
	No.	16–II.	2.95	"

	No. 17.	1.98	per cent.
	No. 17.	2.62	"
	No. 18.	2.54	"
	No. 18.	2.95	"
	No. 18.	2.99	"
	No. 19.	2.69	"
	No. 19.	2.70	"
Method VI. —	No. 1.	1.75	per cent.
	No. 1.	1.90	"
	No. 1.	1.62	"
	No. 6.	.28	"
	No. 6.	.24	"
Method VII.—	No. 1.	.09	"
	No. 13.	.27	"
	No. 14.	.45	"
	No. 15.	1.08	"
	No. 16– I.	.48	"
	No. 16–II.	.49	"
	No. 23.	1.18	"

From the results it seems that Method V. is good, except in case of O. H. steels. Method VI. gave highest on O. H., and about the same as V. on Bessemer steel. The discrepancies in O. H. are in all probability due to a nascent proto oxide of iron, which dissolves very readily in nearly any menstrum.

The oxide in Bessemer steel and muck iron is much more stable.

Thirty minutes with shaking is sufficient to effect solution.

Rapid work is absolutely necessary for accurate results.

The various chlorides, bromides, etc., all exert solvent action.

The paper was discussed by Messrs. Camp, Koch, Unger, and others.

The Society adjourned at 11.15 P. M.

ALEXANDER G. MCKENNA,

Secretary C. S.

I.

METHODS FOR THE ANALYSIS OF ORES, PIG IRON AND STEEL, IN USE IN THE LABORATORY OF THE CARNEGIE STEEL CO., AT HOMESTEAD, PA.

By John S. Unger.*

DETERMINATION OF SILICA IN ORES OF IRON AND MANGANESE.

To 1 gram of the ground ore in an 8 oz. beaker add 35cc. of HCl (1.20 sp. gr.), cover with a watch glass, and boil gently on a hot plate for 20 minutes. Remove and rinse watch glass and sides of beaker with 15cc. of water, filter off insoluble matter on an 11cm. filter, catching filtrate in an 8 oz. beaker, wash with water until all soluble matter is removed. The filtrate, which should not exceed 90cc., is placed on a sand bath and allowed to go to dryness. The filter is ignited and residue fused with 8 grams of carbonate of soda. The fusion is run up around the sides of the crucible and then the crucible is cooled by dipping cautiously in an 8 oz. beaker containing 35cc. water, finally turning the crucible on its side and leaving it. Cover beaker with a watch glass and add HCl gradually until effervescence ceases. After the fusion dissolves out of the crucible, remove with a glass rod and wash the crucible with water. The solution should not exceed 90cc. Evaporate on sand bath to dryness. When both solutions are evaporated, moisten the residues with 10cc. HCl (sp. gr. 1.20) and

* This paper has been received in response to a circular issued by the Chemical Section of the Engineers' Society of Western Pennsylvania, ask-

leave on bath for a few minutes; then add 20cc. hot water, and filter through an 11cm. filter, the first into a 16 oz. Erlenmyer flask, washing out beaker carefully, then filter the second through the same filter. If the alkaline salts have not all dissolved in the second add 20cc. hot water and stir until dissolved, filter and rinse the beaker with hot water until filter is perfectly free from soluble salts. Ignite the filter in a muffle, cool and weigh as pure silica. The filtrate, which is preserved for further use, should not exceed 150cc.

DETERMINATION OF IRON IN IRON ORES.

To the filtrate from silica (given under silica) add 12 grams of B and A shot zinc and 10cc. conc. HCl and place in neck of flask a small funnel. Let the flask stand for about 20 or 30 minutes or until the iron is all reduced. Should the action on the zinc become feeble add 10cc. conc. Hcl. When the iron is reduced test a drop of the solution with a drop of potassium sulphocyanide on a white porcelain plate. If it shows no color or just a very faint pink it is ready for titration. Have ready a 16 oz. wide beaker, a platinum triangle large enough to extend over the edges of the beaker, and a Gooch crucible with a tuft of glass wool $\frac{1}{4}$ inch thick at the bottom. Rinse the funnel into the flask with a wash bottle and pour the solution through the Gooch crucible, receiving the solution in the beaker. Rinse out flask 3 times with about 10 or 15cc. of water and wash the Gooch crucible once. To the filtrate in the beaker add 5cc. conc. Hcl and place on a hot plate for 2 minutes. The solution will now occupy 225cc. Remove from the heat and titrate with standard bichromate solution, using 3 drops for each test toward the end, and adding the bichromate solution, 5 drops at a time, when almost done. Agitate each test drop by blowing gently and continue the addition of the

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ing the co-operation of chemists in an effort to collect for publication the methods in general use for the analysis of iron ores, pig iron and steel.

By order of the Section the Reports of methods are to be published separately. For further information of the members the form of circular issued by the Section is appended at the end of this paper.

bichromate until the last test shows an absence of blue precipitate after agitating and standing 30 seconds. The bichromate used, multiplied by the factor, gives the metallic iron.

The potassium sulphocyanide solution is made by dissolving 10 grams of the salt in 100cc. H_2O and is kept in a small bottle provided with a glass cap and a short piece of $\frac{1}{8}$ inch glass tubing to be used as a pipette in taking out the test drops. The potassium ferricyanide solution is made by dissolving 1 gram of the salt in 100cc. water and test drops are removed as with sulphocyanide. The solution must be made up each day. One drop is used for a test.

The potassium bichromate is made by dissolving 52 grams in 12 litres of water, then shaking well and keeping the stock bottle protected from light.

The porcelain plate is 6 x 6 inches with 12 depressions 1 inch wide by $\frac{1}{4}$ inch deep on its surface.

The bichromate solution is standardized by dissolving 3 portions of about .3 grams, .5 grams and .7 grams of perfectly clean soft iron wire of 99.80 per cent. pure iron in a 16 oz. Erlenmyer flask (having a small funnel in the neck), in 40cc. dilute HCl by the aid of gentle heat. When dissolved rinse the funnel and sides of flask and make solution up to 150cc. Add 12 grams of zinc and when the iron is reduced, titrate exactly as in case of iron in ore. The weight of the wire taken, multiplied by .998 and divided by the number of cc. of bichromade solution used, gives the factor and these factors should agree to the 3rd decimal place.

For iron in manganese ores, the basic acetate precipitate of iron spoken of under manganese is dissolved in 40cc. dilute HCl, the solution made up to 150cc and treated exactly as in the case of the determination of iron in iron ores.

DETERMINATION OF PHOSPHORUS IN STEEL, PIG IRON AND ORES.

Dissolve 1.63 grams of steel in a 6 oz. Erlenmyer flask in 30cc. HNO_3 (sp. gr. 1.20). Place the flask over a burner and

evaporate over naked flame to 15cc., add to the boiling solution 20cc. chromic acid solution, and again evaporate to 18cc., remove from fire and wash down sides of flask with from 5 to 7cc. H_2O and cool to 40° or 45° centigrade. Add 60cc. molybdate solution, previously filtered and heated to 40° or 45° centigrade, insert a stopper in flask and shake for 5 minutes. Leave stand in warm place for 15 minutes, then filter through a 7 cm. (B and A, A grade) filter, (previously dried and weighed at 110° centigrade), and wash with a 2 per cent. nitric acid solution until free from iron, then twice with 95 per cent. alcohol. Dry 20 minutes at 110° centigrade and weigh. Each milligram corresponds to .001 phosphorus.

For pig iron dissolve 1.63 grams, in a 4½ inch evaporating dish, in 40cc. HNO_3 (sp. gr. 1.20), evaporate to dryness on a sand bath. Then place on a burner and heat over naked flame until the mass ceases to evolve red fumes, allow dish to cool and add 25cc. HCl (1.20 sp. gr.), cover with a watch glass and evaporate to 10cc. Add cautiously 25cc. HNO_3 (sp. gr. 1.42) and evaporate to 12cc., remove from burner, rinse watch glass and sides of dish, with 12cc. H_2O, filter through an 11cm. filter into a 6 oz. flask and wash with H_2O. The solution should not exceed 50cc. Heat to 40° centigrade, add 60cc. molybdate solution previously filtered, and heated to 40° or 45° centigrade, shake and finish as for steel.

For manganese ores dissolve 1.63 grams in 40cc. Hcl (1.20 sp. gr.) in a 4½ inch evaporating dish, by gentle boiling, then evaporate to dryness on sand bath, add 25cc. HNO_3 (sp. gr. 1.42) and evaporate to 12cc., dilute with 12cc. H_2O and filter through an 11cm. filter into a 6 oz. flask. The solution should not exceed 50cc. Heat to 40° or 45° centigrade, precipitate and finish as in case of steel.

For iron ores if no phosphorus exists in the insoluble residue and the ore is easily decomposed, proceed exactly as for manganese ore. Should phosphorus exist in the insoluble residue, dissolve 1.63 grams in 40cc. HCl (1.20 sp. gr.) in an 8

oz. beaker by gentle boiling for 20 minutes, dilute with 20cc. H_2O and filter into an 8 oz. beaker, washing with H_2O, set filtrate on sand bath and leave evaporate to dryness. Ignite residue and then fuse with 8 grams of Na_2CO_3 and dissolve fusion as for iron in ore, evaporate the solution to dryness on a sand bath, add to each beaker 25cc. HNO_3 (1.42 sp. gr.), and evaporate carefully to 12cc., dilute with 12cc. H_2O and filter both through an 11cm. filter into an 8 oz. flask, using the same filter for both solutions. Wash with H_2O, heat to 40° or 45° centigrade and proceed as for steel.

The chromic acid solution is made by dissolving 30 grams of pure chromic acid in 2 litres of HNO_3 (1.42 sp. gr.), at a gentle heat. It must be made up fresh at least every two weeks.

The molybdic acid solution is made by mixing 100 grams MO_3 to a paste with 265cc. H_2O, then adding 155cc. NH_4OH (.90 sp. gr.) and stirring until all is dissolved. To this solution add 66cc. HNO_3 (1.42 sp. gr.) stir and set aside for an hour. In another vessel make a mixture of 395cc. HNO_3 (1.42 sp. gr.) and 1100cc. H_2O. Then pour the first solution into the second in a small stream, stirring constantly. Let stand for 24 hours when it is ready for use.

The filter papers for weighing the yellow precipitate are B and A 7cm. "A" grade. These retain the precipitate without its showing a tendency to pass through, and do not contain an appreciable amount of soluble matter, which might be extracted by the acid solution.

The stand for the evaporation over the burners is made of 1 inch angle iron bent and fitted with $\frac{1}{4}$ inch asbestos mill board, having a $2\frac{1}{4}$ inch hole over each burner; this supports the flask easily and prevents the solution from baking on the sides.

The drying bath is a copper drum with a coil of 1 inch steam pipe at bottom and fitted with a movable disk, near the top having $\frac{1}{2}$ inch holes, through which the stem of the funnel

is inserted, the whole being covered by a lid. Steam is supplied at boiler pressure and a temperature of 110° centigrade with very little fluctuation is constantly maintained.

DETERMINATION OF MANGANESE IN MANGANESE ORES.

To the filtrate from silica previously spoken of, add NH_4-OH. When almost neutral, add it drop by drop until the solution assumes a redish brown color. When the last drop produces a reddish brown precipitate, which does not dissolve on shaking, add 10 to 15cc. of ammonium acetate and bring to a boil. Boil one minute. Then remove and let the precipitate settle, filter through a 12½cm. filter, catching the filtrate in a 16 oz. beaker, wash out flask once with hot water. When the filter has run dry, place a funnel in the flask, and dissolve precipitate in 15cc. dilute HCl (1 to 1), wash iron out of paper and repeat the precipitation with ammonia and ammonium acetate, combining the filtrates. Wash the precipitate 3 times with hot water and reserve for the estimation of iron. To the filtrate add 3 drops of solution of phenolphthalein, then ammonia until pink, then 3cc. in excess. Pass a current of H_2S through the solution for 10 minutes, rinse delivery tube and set beaker on sand or steam bath for 30 minutes, filter through a double-pointed 7 and 11cm. filter, and wash with dilute NH_4HS water. When washed place a clean 12 oz. beaker under funnel and pour over precipitate 40cc. of a mixture of 20cc. hot water and 20cc. of 50 per cent acetic acid, keeping the funnel covered with a watch glass. If the manganese sulphide does not all dissolve pour the solution through the filter again, wash filter 4 times with hot water, and place beaker on a hot plate. Boil for 15 minutes, dilute to 150cc; add 15cc. ammonium phosphate, and if a precipitate forms, add a few cc. of HCl until dissolved, bring to a boil and then precipitate by adding NH_4OH, drop by drop until the solution smells of NH_4OH. While precipitating stir constantly to bring the

precipitate down in a granular form, filter through a 12½cm. filter, using suction, ignite in muffle and weigh as $Mn_2P_2O_7$.

The ammonium acetate solution is made by dissolving 120 grams in 2000cc. water, then filtering.

The ammonium phosphate is a saturated solution of the salt in cold water, diluted with an equal bulk of water.

DETERMINATION OF SILICON IN PIG IRON.

Weigh into a 4½ inch evaporating dish .9333 grams of sample, cover with a watch glass, then add 50cc. of a mixture of 10cc. H_2SO_4, sp. gr. 1.83, and 40cc. H_2O. Place over a Bunsen burner, supporting the dish on a piece of ¼ inch asbestos board, having a 2¼ inch hole in the center, and evaporate until dense, white fumes escape, and the drop of water which condenses on the watch glass falls back into the dish with a hissing sound. Remove dish from fire and let cool for 2 or 3 minutes. Then cautiously add 50cc. of a mixture of 10cc. HCl, sp. gr., 1.20, and 40cc. H_2O, place over burner and bring to a boil. Boil gently for one minute, remove from the fire, rinse the watch glass and filter the solution through an 11cm. filter. Wash once with water, then with dilute HCl (1 to 1) and finally with water until free from iron.

Ignite the precipitate in the muffle, cool and weigh. To the residue in the crucible add from 4 to 10 drops pure HFL, depending on the amount of silica present. Drive off excess of acid by heating gently on a hot iron plate, then ignite for 2 or 3 minutes in muffle, cool and weigh.

The difference in weight is divided by 2, and a decimal point inserted 2 places from the right hand gives the percentage of silicon in sample.

DETERMINATION OF SULPHUR IN PIG IRON AND STEEL.

Weigh 5 grams of the sample into a 16 oz. side-necked flask, fitted with a rubber stopper and thistle tube. An 8 oz. beaker of the tall, narrow shape, containing 15cc. of cadnium

solution and filled to within one inch from top with water, is placed under the delivery tube. Then 90cc. of a mixture of 40cc. HCl, sp. gr. 1.20, and 50cc. H_2O is poured into the thistle tube and the apparatus is placed on a stand made of $\frac{1}{4}$ inch asbestos mill board, having a $2\frac{1}{4}$ inch hole at one side and heated by a Bunsen burner. The heating is so regulated that the evolved gases are delivered at about 3 bubbles per second. As the action grows feeble, the heat is increased, until finally when all is dissolved, the solution is brought to a boil and kept boiling for one minute. The delivery tube is then raised out of the beaker and the flask is set aside.

The contents of the beaker are then poured into a 12 oz. wide beaker, the precipitate is washed out of the beaker with a wash bottle, and 5cc. starch paste are added. 35cc. of a mixture of 40cc. HCl (sp. gr. 1.20) and 50cc. H_2O are then poured into the absorption beaker and rinsed into the solution in the large beaker. The sulphur is then immediately titrated with standard iodine solution.

The iodine solution is made by dissolving 8 grams iodine and 30 grams potassium iodide in 200cc. cold water and then diluting to about 1850cc. A standard steel is then tested by the method and the result noted, and from this the amount of water needed to dilute the iodine, so as to bring it to the required strength is calculated. After diluting two determinations are made on the standard steel to see that the iodine solution is exactly right. The iodine solution is made of such strength that 1cc.=.01 per cent of sulphur in the sample. Two litres of standard iodine are made up at once and the solution is preserved in a dark cupboard The amount actually in use is kept in a special burette having a blackened receiver to exclude light. The stock solution is standardized every week.

The cadnium solution is made by dissolving 300 grams cadnium chloride in 1000cc. hot water in a large bottle and then adding 1500cc. NH_4OH (sp. gr. .90), filtering through a pleated filter into a 12 litre bottle. 6500cc. NH_4OH (sp. gr.

.90) are then added to the solution and 3000cc. H_2O. The whole is well shaken when it is ready for use.

The starch paste is made by heating 1000cc. water to boiling point in a 1200cc. flask and adding gradually 10 grams of starch made into a cream with 50cc. cold water. Keep the solution boiling constantly. When all the starch is added boil 5 minutes, then set aside to cool, decant the liquid, throwing the last 50cc away.

The solution is made up every three days.

DETERMINATION OF CARBON IN STEEL.

5 grams of the sample are weighed into a clean 8 oz. flask and 200cc. of copper potassium chloride are added, the flask is closed with a rubber stopper and shaken until the precipitated copper is completely redissolved, which is easily detected by the absence of copper covered particles at the bottom of the flask. Remove and rinse the stopper, then filter through a perforated platinum boat, having a layer of asbestos $\frac{1}{8}$ inch thick at bottom and held in a platinum holder. Wash the residue twice with concentrated HCl, then with water until all the soluble matter has been removed. Dry the boat for two hours at 90° centegrade, when it is ready for burning. Introduce into the combustion tube, pushing it against the roll of silver foil, start a current of oxygen from the cylinder through the apparatus at 2 to 3 bubbles per second. In the meantime weigh the potash bulb and the small calcium chloride tube filled with solid KOH. Attach the bulb and tube to the apparatus and light first two burners and leave burning for 5 minutes to heat platinum gauze in combustion tube to redness, then light the next burner and leave burning 2 minutes, following this by the others in exactly the same way. When all are lighted leave burning 5 minutes. Then shut off the oxygen and start the air current, being careful to make the change without allowing any back pressure from the air in the room. Aspirate air for 40 minutes, using 1000cc., and weigh.

The copper potassium chloride solution is made by saturating 2 liters of cold water with the salt, adding to the solution 100cc. of HCl (sp. gr. 1.20), then 1 gram of a high carbon steel, shaking until dissolved, then filtering the whole solution into a 2 litre bottle, through an asbestos filter.

The asbestos is prepared by rubbing the ignited fibre through a 20 mesh sieve by a gentle stream of water, receiving the water and pulp in a large vessel, allowing the pulp to settle and drawing the water off by a syphon. Cover the pulp with strong, hot HCl, and digest over night, draw off the acid with a syphon and wash with water by decantation until free from acid, pour into a bottle with water sufficient to cover it, and when needed shake the bottle before drawing out a portion.

The purifying of the air and oxygen is effected in an apparatus having one side fitted to the aspirator bottles supplying the air, while the other side connects directly with the oxygen cylinder. The wash bottles are glass stoppered, filled to $\frac{1}{2}$ height with KOH (sp. gr. 1.30), the attached $CaCl_2$ jars are filled to $\frac{1}{2}$ height with solid KOH, the balance with $CaCl_2$ and a plug of glass wool on top; a Y tube connects each side with the combustion tube.

The combustion tube is of platinum, $\frac{3}{4}$ inch bore, with a body 20 inches long, having $\frac{3}{16}$ inch platinum tubes 3 inches long extending from the body. The tube contains a roll of platinum gauze 4 inches long, filling the bore of the tube and pushed into combustion tube until the anterior end is over the first burner, this gauze is followed by a roll $1\frac{1}{2}$ inches long, of silver foil inclosed in a piece of platinum foil, which just fills the bore of the tube, and this is then followed by the boat; the tube being closed by a cone-shaped ground joint which is reinforced by bands of nickel.

The combustion furnace is an ordinary 10-burner Bunsen furnace.

The absorbing train is made up of 2 U tubes giving a total length in tubes of 44 inches; these are followed by a Geissler potash bulb containing KOH solution (sp. gr. 1.30), (after a bulb has absorbed about ½ gram CO_2 a fresh one is used), and a 4 inch $CaCl_2$ tube containing solid KOH. The bulb and tube are weighed, and these are followed by an 8 inch $CaCl_2$ tube filled with solid KOH to prevent any CO_2 from the outside air entering the apparatus. The first U tube of the train is filled for the first 5 inches of its length with granulated silver. This silver is removed from time to time as it becomes dark colored on the surface, ignited and replaced in tube. The silver is followed by 17 inches of $CaCl_2$. In the next U tube there are 11 inches of $CaCl_2$, then 11 inches of anhydrous $CuSO_4$, followed by a plug of glass wool. The $CuSO_4$ is renewed after every 5 combustions. When the U tubes are first filled a combustion is made in the ordinary manner, but no weighings made, the object being to saturate any caustic lime which might be in the $CaCl_2$ used. The entire train is supported on a special support which permits of adjustment in a vertical or horizontal direction.

DETERMINATION OF MANGANESE IN STEEL.

Weigh 200 milligrams of steel into a 2 oz. flask, add 20cc. of 1.20 HNO_3. When dissolved, boil gently for 5 minutes, remove and pour the solution into a 100cc. graduated cylinder. Wash out flask 3 times with H_2O, finally dilute to 100cc. mark. Pour the contents into a 4 oz. precipitating jar and mix by pouring into cylinder or jar at least three times, draw off 25cc. with a pipette into the flask in which the solution was made, add 6cc HNO_3 (1.20 sp. gr.) from a burette, place on a hot plate together with a standard in which the manganese is exactly known and which has been treated exactly like the steel, and when almost boiling add ½ gram lead, peroxide, measured approximately on a small glass spatula, and boil for 3 minutes. Remove, place in a cooling bath, and allow the PbO_2 to settle, which usually requires 15 minutes.

Decant the solution into a comparison tube and compare with the standard properly diluted as for color carbon determination.

DETERMINATION OF MANGANESE IN PIG IRON.

Dissolve as for steel, place a small funnel in the cylinder and filter. Wash the residue thoroughly, being careful not to allow the washings to exceed 100cc., treat the filtrate as in case of steel.

DETERMINATION OF NICKEL IN STEEL.

Dissolve 1 gram of steel in 25cc. HNO_3 (sp. gr. 1.20) and boil in a 100cc. flask, until solution is complete. Wash contents of flask into a ½ gallon flask containing 700cc. hot water, add 100cc. sodium acetate solution and bring to a boil for one minute. Remove from plate and let settle for 3 minutes, filter through a 38½cm. pleated filter into a litre beaker, allow the precipitate to run dry. To the filtrate, which should be perfectly clear and almost colorless, add 3 drops phenolphthalein, then NH_2OH until pink, place on hot plate and pass a current of H_2S gas through the solution for 10 minutes, remove from the plate and add 12cc. ascetic acid (50 per cent.), stir and allow the precipitate to coagulate on warm plate for 10 minutes, filter through a 12½cm. filter and wash with H_2S water made slightly acid with acetic acid. Roast in a platinum crucible, carefully at a low red heat (usually at the front of muffle) until the paper has just burned off. Take out crucible and break up the precipitate with platinum rod to powder, then place in the muffle and ignite for 15 minutes at a bright red heat, cool and weigh. To the crucible add 3cc. (1 20 HCl), cover with a watch glass and warm gently on a plate until the precipitate has dissolved. Wash into a 150cc. beaker with H_2O, add NH_4OH until the solution smells strongly of NH_4OH and filter from the SiO_2 and $Fe_2(OH)_6$. Redissolve precipitate in 3cc. HCl and repeat the precipitation with NH_4OH, wash with hot H_2O, ignite in same crucible and

weigh. The difference in the weight gives the NiO. A correction of 5 per cent. on the quantity of nickel present is made to provide for the nickel remaining in the basic acetate precipitate.

The sodium acetate solution is made by dissolving 3000 grams of sodium acetate in 12000cc water.

Chemical Section Engineers' Society of Western Pennsylvania.

In accordance with a resolution of the Chemical Section of the Engineers' Society of Western Pennsylvania, the undersigned wish to ask your co-operation in an effort to collect for publication in the Proceedings of the Society the methods of analysis in use in the various iron and steel works laboratories of the region.

In calling the attention of Chemists to the plan and asking their aid in its fulfillment, it should be mentioned that it is the aim of the Section to secure accurate statements of analytical processes, describing with minuteness and clearness the successive steps, in order that the proposed compilation may represent as correctly as possible the present status of analytical chemistry as applied to iron and steel.

A full presentation of the methods in general use is likely to prove of interest and value, but the completeness and promptness of the responses received from a large number of Chemists must determine the success of the measure.

In case you are willing to co-operate, you are requested to send to any one of the undersigned a full description of the methods you use for the determination of the following substances :

In Ores:	*In Pig Iron:*	*In Steel:*
Silica,	Silicon,	Carbon (by combustion),
Iron,	Sulphur,	Sulphur,
Phosphorus,	Phosphorus,	Phosphorus,
Manganese.	Manganese.	Manganese,
		Nickel.

SUGGESTIONS.

1. If the method is described in a text-book or journal, a mere reference will suffice, but any deviations from the published methods should be noted.

2. In writing a description of a method it is very desirable that minute details should be given (e. g., weights taken, volumes of solution, temperature, etc., etc.)

3. If more than one method is used, please describe the the one in every day use on which the commercial transactions of the firm are based.

4. It is earnestly requested that a reply be sent at the earliest possible date.

Each method will be published over the name of the sender. The work of the Committee will be confined to collecting and arranging for publication without comment or discussion.

COMMITTEE:
F. C. PHILLIPS,
Western University, Allegheny, Pa.
A. G. MCKENNA,
Duquesne Steel Works, Duquesne, Pa.
E. S. JOHNSON,
Black Diamond Steel Works, 30th and Smallman Sts., Pittsburg, Pa.

II.

METHOD FOR THE ANALYSIS OF IRON ORES, PIG IRON AND STEEL IN USE AT THE LABORATORY OF THE MONONGAHELA FURNACE, M'KEESPORT, PA.

By Frederick Crabtree.

DETERMINATION OF SILICA IN ORES.

.5 gram or one gram of the ore (powdered to pass through a 100-mesh sieve) are fused with sodium carbonate, the fusion dissolved in dilute hydrochloric acid, and the solution evaporated to dryness in a 5½-inch or 6-inch R. M. evaporating dish. When the residue is thoroughly dry, dilute hydrochloric acid is added and the mixture boiled until the iron is dissolved. The solution is then filtered, the silica washed with hot water, ignited and weighed.

DETERMINATION OF IRON IN ORES.

.5 gram of the ore are placed in a 2-oz. beaker with about 35-40 cc. of strong hydrochloric acid, and allowed to stand on a steam bath for several hours (usually over night). Sometimes several drops of stannous chloride are added to hasten the solution. When ready for titrating, the contents of the beaker are heated to boiling and examined to see if the residue is white; a slight excess of stannous chloride solution is added, the mixture placed in a 20-oz. beaker and diluted with about 300 cc. of cold water. About 25 cc. of cold saturated solution of mercuric chloride are then added and the solution titrated with a bichromate solution containing about 4.38 grams per litre.

DETERMINATION OF PHOSPHORUS IN ORES.

Two to five grams of the ore are digested with 75—150 cc. of strong hydrochloric acid and the solution evaporated to hard dryness. About 100 cc. of strong hydrochloric acid are poured on the residue and the mixture boiled until the solution is concentrated to about half that volume. Water is then added and the diluted solution filtered, keeping the volume of the filtrate as small as is convenient.

The solution is then evaporated with nitric acid until the hydrochloric acid is driven off. The insoluble residue is ignited; the silica driven off by boiling with hydrofluoric acid. The residue is fused with sodium carbonate, the fusion dissolved in nitric acid and the solution filtered into the main solution. To this ammonia water is next added (the fluid is now in a 16-oz. Erlenmeyer flask) until the solution becomes pasty and smells ammoniacal; the precipitate is dissolved in a slight excess of nitric acid and the solution brought to a temperature of 80° C., when 40 cc. of the molybdate solution are added.

A current of air is used to agitate the solution for about five minutes; the latter is filtered while still warm. After washing thoroughly with distilled water, the yellow precipitate is titrated according to the KOH-HNO_3 method (Hundeshagen, Zeit. Anal. Chem., 1889, p. 171, and Handy, Proc. Eng. Soc. W. Pa., 1892, p. 78).

Sometimes the method is varied by not evaporating with nitric acid to drive off hydrochloric acid after filtering from the insoluble residue; the insoluble residue may then be fused, the fusion dissolved in nitric acid and the solution evaporated to dryness to get rid of silica.

DETERMINATION OF MANGANESE IN ORES.

The filtrate from the silica determination is nearly neutralized by ammonia water, and then ammonium carbonate solution added until the iron is on the point of coming down, the solution still remaining clear. The addition of a solution con-

taining about 2 grams of ammonium acetate and hot water enough to give a volume of about 400–500 cc. will cause the precipitation of the iron and alumina. The contents of the beaker are heated to boiling and boiled for about one minute. The precipitate is filtered off and washed with hot water immediately. The manganese in the filtrate is precipitated by bromine and ammonia, and usually weighed as Mn_3O_4.

DETERMINATION OF SILICON IN PIG IRON.

One gram of drillings is dissolved in 20–25 cc. of nitric acid (1.20) and 8–10 cc. of dilute sulphuric acid (1:3) and evaporated in a 5-inch R. M. dish until the sulphuric fumes are given off copiously. The residue is treated with dilute hydrochloric acid and the mixture boiled; the residue is filtered off and washed with hot water and dilute hydrochloric acid, ignited and weighed as SiO_2.

DETERMINATION OF SULPHUR IN PIG IRON.

The evolution method is ordinarily used, catching the sulphur by a dilute ammoniacal solution of cadmium chloride, and titrating with iodine solution without filtration.

DETERMINATION OF PHOSPHORUS IN PIG IRON.

Five grams of Bessemer pig iron are dissolved in 100 cc. of dilute nitric acid (30 per cent. of 1.42 HNO_3); the loss due to evaporation is made good by diluting to just 100 cc., and the solution then filtered. Eighty cc. of the filtrate are boiled, oxidized by permanganate solution and the manganese oxide dissolved by the addition of hydrochloric acid. The solution is made ammoniacal, the precipitate redissolved by nitric acid; to the solution, at a temperature of 75°–80° C., 40 cc. of molybdate solution are added, and a current of air used to agitate the liquid for about five minutes. The solution is filtered while warm, the precipitate being washed with cold water, and then titrated with a caustic potash solution, 1 cc. of which is equivalent to .0002 gram P.

DETERMINATION OF MANGANESE IN PIG IRON.

Titration by permanganate. One gram of the pig iron is dissolved in dilute nitric acid (25 cc. water, 15 cc. HNO_3, 1.42 sp. gr.); the solution is evaporated nearly to dryness, diluted with water, a slight excess of zinc oxide being mixed with the water added, and the volume made up to 500 cc. by water. After thoroughly mixing, the precipitate is allowed to settle; 250 cc. of the supenatant liquid are decanted and titrated while hot.

DETERMINATION OF CARBON IN STEEL.

Chromic Acid Combustion Method.—Use the following train after the condenser: First, a small empty bottle; second, pyrogallic solution recommended by Committee on International Standards; third, silver sulphate solution; 4th, strong sulphuric acid; 5th, potash-bulb; sixth, small weighed flask containing sulphuric acid to catch any moisture that might be carried over from potash-bulb; seventh, a guard test-tube containing sulphuric acid.

For dissolving the steel use a solution of copper potassium chloride, acidified with hydrochloric acid, and shake or agitate so as to have steel dissolved quickly.

DETERMINATION OF SULPHUR IN STEEL.

Iodine titration; same as pig iron.

DETERMINATION OF PHOSPHOROUS IN STEEL.

Four grams are dissolved in 100 cc. of dilute nitric acid (1.13 sp. gr.), oxidized by permanganate, the precipitated oxide of manganese dissolved by hydrochloric acid, etc., as in case of pig iron.

DETERMINATION OF MANGANESE IN STEEL.

Color Method. 0.2 grams of steel (our steel is soft and contains from 0.25 to 0.45 per cent. manganese, usually) are dissolved in 15 cc. of dilute nitric acid (1.20 sp. gr.). When the solution is clear, and nitrous fumes all gone, 15 cc. of water are added; the solution is brought to lively boiling, lead peroxide added, and the mixture boiled two minutes; a little more lead peroxide is then added, when the flasks are removed from the hot plate and placed in cold water for settling.

III.

METHODS FOR THE ANALYSIS OF ORES, PIG IRON, AND STEEL, IN USE IN THE CHEMICAL LABORATORY OF THE JUNCTION IRON AND STEEL COMPANY, STEUBENVILLE, OHIO.

By Joseph M. Wilson.

DETERMINATION OF SILICA IN ORES OF IRON.

Weigh 1 gram of ore into a 5-inch flat dish, moisten with 10 cc. water, add 30 cc. concentrated HCl, evaporate on hot plate to dryness, and ignite. Moisten with HCl, dry, and ignite again. Cool, moisten with HCl, dissolve in 30 to 50 cc. boiling water, filter, wash with hot HCl (1:1) and with cold water. Burn the filter wet. Mix with 5 to 6 parts Na_2CO_3 and fuse. Dissolve fusion in 50 to 60 cc. water, add HCl till acid, evaporate to dryness, ignite till no further decrepitation occurs, cool, moisten with HCl, dry and ignite (to render silica insoluble), cool, moisten with HCl; take up in boiling water, filter and wash twice alternately with hot HCl (1:1) and cold water; then five or six times with hot water. Burn and weigh as SiO_2.

If greater accuracy is desired, moisten the silica with HFl and add a few drops of H_2SO_4. Evaporate to dryness, ignite, cool and weigh. The loss = SiO_2.

DETERMINATION OF IRON IN ORES.

Solutions employed:—Potassium dichromate; 4.9 grams are dissolved in 1 liter. 1 cc. = 0.005 gram Fe. Stannous chloride; 100 grams are dissolved in 1 liter of hydrochloric acid (1:1). Mercuric chloride; 50 grams are dissolved in 1 liter. Potassium ferricyanide; a piece one-fourth the size of a pea in 40 cc. water.

Weigh .25 and .5 gram ore into small unlipped beakers, moisten with water, add 30 cc. HCl, cover, place on steam table; when solution is complete and residue appears white boil on hot plate, add $SnCl_2$ from pipette till liquid becomes colorless, boil a few moments, remove to steam table till ready to titrate, wash into beaker, dilute to 300–350 cc., stir, pour in excess of $HgCl_2$ (30 to 40cc.), stir, run in $K_2Cr_2O_7$ *at once* until four drops fail to develop a blue color with ferricyanide indicator in one-half minute. Burette reading on half-gram sample gives the per cent. of iron when 1cc. $K_2Cr_2O_7$ = .005 gram Fe. Reading on $\frac{1}{4}$ gram doubled should vary not more than $\frac{2}{10}$ cc. from that on $\frac{1}{2}$ gram.

PRECAUTIONS.—Avoid large excess of $SnCl_2$; one or two drops more than is required to destroy yellow color is sufficient.

In adding $HgCl_2$ pour all in *at once*. If added slowly, metallic Hg is precipitated and the operation spoiled.

DETERMINATION OF PHOSPHORUS IN ORES.

Weigh 10 grams ore into a 5-inch (deep) dish, moisten with water and add 100 cc. HCl; let stand on steam table, evaporate to dryness, heat, cool, moisten with 100 cc. HCl; boil down to a syrup, add 75 cc. water, filter, wash with HCl (1:1) and cold water. Ignite residue, fuse with 5 to 6 parts of Na_2CO_3, dissolve the fusion in water and HCl, evaporate to dryness and heat, moisten with HCl, take up with water, filter, boil filtrate and add a slight excess of ammonia. Filter, wash two or three times with hot water, dissolve in hot nitric acid of 1.2 specific gravity, add to main solution, which has in the meantime been evaporating to a syrup, add 75 cc. HNO_3 and again evaporate to a syrup, transfer to a 16-oz. flask and add an excess of ammonia, redissolve the ppt. in HNO_3 in very slight excess, warm to 87° C., add 50–75 cc. of molybdate solution, shake five minutes, let settle, filter, wash with ammonium sulphate solution till free from iron.

The ammonium sulphate solution is made by diluting and mixing 48 cc., H_2SO_4 and 55 cc. NH_4OH, and then making up to 2 liters.

The molybdate solution is prepared according to Woods' formula. (Proc. Engineers' Society Western Pennsylvania, Vol. viii, 1892, p. 80.)

A stream of air is blown through the fluid while adding the molybdate solution to nitric acid.

The yellow precipitate is dissolved in ammonia; 5 to 10 cc. magnesia mixture are added, the fluid well stirred and allowed to stand for two hours; filter and without washing redissolve the ppt. in HCl. The bulk of the fluid must be kept below 25 cc. A piece of citric acid half the size of a pea is added and then ammonia in slight excess. After stirring the fluid is set aside for 15 to 20 minutes, stirring occasionally. The solution is now diluted with an equal bulk of ammonia and allowed to stand from 12 to 24 hours. Filter, using a Gooch crucible; wash with a solution of ammonium nitrate containing 50 grams NH_4NO_3 in 2 liters NH_4NO_3, (1:3); burn and weigh. Or, the yellow precipitate is dissolved in sodium hydroxide and titrated with standard nitric acid, according to Hundeshagen, Zeit. Anal. Chem., 1889, p. 171; or, the precipitate is dissolved in ammonia, the solution acidulated with sulphuric acid and the phosphorus determined volumetrically by permanganate, according to Emmerton (Blair, Analysis of Iron, p. 85.)

DETERMINATION OF MANGANESE IN ORES AND IN METALS.

Volhard's Me thod:—This method was described by Emmerton Trans. A. I. M. E., Vol. X., p. 204, and is as follows: "Evaporate solution—peroxidized—with H_2SO_4 in excess, till copious fumes of SO_3 are evolved, cool, take up in water, filter into 300 cc. graduated flask, add Na_2CO_3 till color is wine red, but no precipitate forms, then ZnO suspended in water till color is light brown (or perhaps fawn), mix by pouring into beaker and back several times, filter through 10-inch dry fluted filter, take 200 cc. of filtrate in 16-oz. flask, to which add 2 drops HNO_3, sp. gr. 1.42, boil, run in $KMnO_4$ a little at a time, shake vigorously to make ppt. collect, let settle, repeat till a permanent pink is obtained.

NOTES.—This method is not applicable to substances carrying less than $\frac{8}{10}$ per cent. Mn, owing to the difficulty in distinguishing the color of MnO_2 from the *pink* of $KMnO_4$. When the substance carries more than 5 per cent., take 100 cc., or even less, instead of 200 cc.

Pig iron is to be treated as for silicon, then filtered, the filtrate evaporated a *second* time with H_2SO_4, proceeding then as above described.

The permanganate solution contains 1.27 grams $KMnO_4$ per liter.

1 cc. = 0.002262 gram Fe, or 0.000666 gram Mn, corresponding to $\frac{1}{10}$ per cent. Mn when $\frac{2}{3}$ gram of the sample is used.

Color Method:—Weigh 0.2 gram of the sample into an eleven inch tube, add 20 cc. HNO_3 (1.2 sp. gr.), boil till the escape of brown fumes ceases, add 10 cc. water, boil, add about 3 grams PbO_2 and continue boiling for $2\frac{1}{2}$ minutes. Place in cold water until the fluid has become clear; decant into the reading tube and compare.

Use pig iron or steel in which the Mn has been determined gravimetrically: (*a*) By Ford's method; (*b*) by acetate method, as a standard. Weigh standard with each batch to be read. Manganese is also determined by precipitation by bromine, and weighing as Mn_3O_4.

DETERMINATION OF SILICON IN PIG IRON.

Drown's method is used.

DETERMINATION OF SULPHUR IN PIG IRON.

By method described by Emmerton (Trans. Am. I. M. E., Vol. X.), absorption of H_2S in KOH (Powers & Weightman's white stick caustic is the only brand that will give uniformly correct results) and titration with iodine solution. 1 cc. = .0005 gram S. Standardize by a *steel* of known S. content. Results check with those obtained by the *aqua regia* method. When solution is *complete*, boil till steam reaches the stopper of the first tube, put out the light, open

the stop-cock in funnel, and let stand till liquid in tube is cold. Wash into a beaker, making the volume up to 300–400 cc., add starch solution 3-5 cc., then excess of HCl, titrate with iodine solution, of which 1 cc. = .0005 gram S. Standardize the iodine solution with steel or pig iron, the S content of which has been determined as indicated.

PRECAUTIONS.—Be sure that the metal is *entirely* dissolved. Pig irons high in sulphur frequently dissolve very slowly and *must be watched carefully*. The method for sulphur determination described by N. W. Lord (Notes on Metallurgical Analysis, p. 52) is to be highly recommended.

DETERMINATION OF PHOSPHORUS IN PIG IRON.

Follow Emmerton till the yellow precipitate is obtained, then Hundeshagen, (loc. cit.), and Handy (Proc. Eng. Soc. W. Pa., 1892, p. 78.)

DETERMINATION OF MANGANESE IN PIG IRON.

Color method, using a pig iron standard; also Ford's method for the purpose of checking.

DETERMINATION OF CARBON IN STEEL.

Ullgren's method, as described by McCreath in Trans. A. I. M. E., Vol. V., p. 575, is followed, checking by combustion in platinum tube. As the solvent ammonio cupric chloride in saturated solution is used.

The chromic acid solution contains 80 cc conc. sulphuric acid (previously purified by the addition of a little chromic acid) and 10 cc. of a saturated solution of chromic acid crystals. Not more than 20 cc. of water are used in rinsing the carbon into the combustion flask. Soda lime is the absorbent for the carbon dioxide evolved.

The method for the determination of sulphur and phosphorus are the same as in the case of cast iron.

Manganese is determined by color; checking by Ford's method.

Nickel is determined according to the method of Eastwick.

IV.

METHODS FOR THE ANALYSIS OF ORES, PIG IRON AND STEEL, IN USE IN THE LABORATORY OF THE CARNEGIE STEEL COMPANY, LUCY FURNACE, PITTSBURG, PA.

By Robert Miller.

DETERMINATION OF SILICA IRON AND PHOSPHORUS IN IRON ORES.

I use the methods described on pages 19, 16, 22–26, respectively, of "Notes on Metallurgical Analysis," by N. W. Lord.

DETERMINATION OF SILICON AND SULPHUR IN PIG IRON.

On pages 37 and 35, respectively, of the above work will be found described the methods used by me for this purpose.

DETERMINATION OF MANGANESE IN PIG IRON.

Volhard's method, as described by Blair, is used for this determination.

DETERMINATION OF PHOSPHORUS IN PIG IRON.

Weigh off 1–5 grams of iron (according to the amount of phosphorus present), put into a 4-oz. beaker, and add cautiously 25–75 cc. nitric acid (1.20 sp. gr.). After the violent action has ceased, boil down to dryness, and bake for 30 minutes. Allow to cool, dissolve the mass in 20–40 cc. of concentrated hydrochloric acid and evaporate the solution to 10 cc. Add 20 cc. of water and filter. Now add ammonia until ferric hydrate separates out, the mass becomes thick and smells of the precipitant. Redissolve the precipitate in strong nitric acid, adding the acid gradually and until the liquid has

an amber color. Without previously heating the solution, add 40 cc. of molybdic acid and allow the yellow precipitate to settle. The phosphorus is all down in about 10 minutes. Filter on a 9 cm. filter and wash with acid ammonium sulphate. Dissolve the precipitate in 5 cc. of strong ammonia (diluted with 25 cc. of water) and allow to run into the flask in which the precipitation was made. Wash the filter until the volume of the filtrate is 150 cc. Add 10 cc. of concentrated sulphuric acid, dilute to 200 cc. and filter through the reductor. The reduced solution is titrated with potassium permanganate.

The acid ammonium sulphate used in washing the yellow precipitate is made by adding 27.5 cc. of ammonia (0.96 sp gr.) to 500 cc. of water, to this 24 cc. of strong sulphuric acid (c. p.), and making the whole up to 1 litre.

To prepare the molybdic acid solution, add to 100 grams of molybdic acid 200 cc. of water and then 160 cc. of ammonia. This dissolves all the acid. Pour the filtered solution into 1000 cc. of nitric acid (1.20 sp. gr.). Let the mixture stand a day or two before using.

V.

METHODS FOR THE ANALYSIS OF IRON ORES, PIG IRON AND STEEL USED IN THE LABORATORY OF THE BLACK DIAMOND STEEL WORKS, PITTSBURGH, PA.

By Edward S. Johnson.

I. IRON ORES.

1. *Silica.* 1–3 grams of the finely pulverized ore are digested upon the water-bath in a covered beaker with 10–30 cc. of concentrated hydrochloric acid until decomposition is complete. The solution and siliceous residue are then transferred to a porcelain dish, and the solution evaporated on the graphite-bath (substitute for the sand-bath) to dryness. The residue is taken up with concentrated hydrochloric acid and water, the solution evaporated as before, and, after redissolving the dry mass in concentrated acid and dilution with several volumes of water, the siliceous residue is collected upon a Swedish filter, thoroughly washed, and ignited in a platinum crucible. After ignition the residue is subjected to a fusion with 10 to 15 times its weight of sodium carbonate. The fusion is dissolved in water and hydrochloric acid, the solution evaporated to dryness on the water-bath, and the separation of the silica further conducted as usual under the given circumstances. The insoluble residue remaining after the fusion, etc., is weighed ordinarily as SiO_2.

In still more accurate determinations, the silica thus obtained is treated with hydrofluric and sulphuric acids. The loss after evaporation and ignition is silica.

2. *Iron.* The process for the determination of iron in iron ores is the familiar one, consisting in the solution of the ore in the least possible quantity of concentrated hydrochloric acid, reduction of the resulting ferric or ferro-ferric to a ferrous solution, and titration of the highly diluted solution, in the presence of a large excess of sulphuric acid, with potassium permanganate.

.4–.5 gram of the sample are dissolved in a covered 10 in. × 1 in. test-tube in 4–5 cc. of concentrated hydrochloric acid. The tube is heated over a small gas flame, at first warmed only, and later, as the reaction proceeds, to gentle boiling. A small crystal (.1–.2 gram) of potassium chlorate is added to the solution to oxidize possibly present organic matter, and the boiling continued, with addition of more hydrochloric acid, if necessary, for some minutes in order to decompose an excess of chlorate.

When all but a flocculent siliceous residue has been dissolved, the watch-glass covering the tube, and the walls of the tube are rinsed down with water, and 3–4 grams of triturated zinc added to the solution. The resulting brisk evolution of hydrogen soon slackens ; a few cubic centimeters of dilute sulphuric acid (1 vol. conc. acid + 1 vol. water) are poured into the tube, and heat is applied, with addition of more dilute sulphuric acid as required, until the colorless condition of the solution indicates the complete reduction of ferric salt, and all zinc has dissolved. The remainder of 25 cc. of concentrated sulphuric acid (diluted with 1 vol. of water) is next added, and the reduced solution transferred from the test-tube to a 600 cc. beaker. Sufficient cold, freshly-boiled distilled water to make the volume of the solution 400–500 cc. is poured into the beaker. From a 50 cc. Gay-Lussac burette, a solution of potassium permanganate (1 cc. representing about .0068 gram of iron), standardized by oxalic acid, is run into the diluted ferrous solution until finally one drop imparts to it a permanent pink coloration. From the number of cubic centimeters

used in the titration, a deduction is made for the volume of permanganate solution required to produced the above end-reaction with all materials present or applied in the operations just described, *i. e.*, acids, zinc, ferric chloride, water, etc. The remainder forms obviously the basis for the calculation of the percentage of iron.

3. *Phosphorus.* This element is separated as ammonium phospho-molybdate and weighed in the same form.

1.63 gram of ore are weighed off into a small porcelain dish and ignited gently. When it has sufficiently cooled, the sample is treated with about 20 cc. of concentrated hydrochloric acid, and the mixture, with frequent stirring, is heated on the water-bath until all but siliceous matter has dissolved. The solution is evaporated to dryness, and the residue redissolved in 20–30 cc. of hydrochloric acid. This second hydrochloric solution is evaporated until the separation of basic chloride of iron begins. With two or three drops of acid, the solution is restored ; 30–40 cc. of water are added, and the insoluble siliceous residue is filtered off. The filtrate, which should have a volume of about 60 cc., is ready for the precipitation which is effected as described below for steel : III. 3.

4. *Manganese.* According to the percentage of manganese present, the colorimetric or a gravimetric method is applied for its quantitative determination—for quantities up to about three per cent., the former, for higher percentages, the latter.

COLORIMETRIC METHOD.

From .05–.10 gram of ore are placed in a 6 in. × ½ in. test-tube, and dissolved in 2–3 cc. of concentrated hydrochloric acid which is then expelled by boiling with an excess of concentrated nitric acid of 1.42 sp. gr. The nitric acid solution is poured into a 10 in. × 1 in. test-tube, rinsed out of the smaller tube with 32 per cent. nitric acid, and diluted

with the same to a volume of about 35 cc. By the addition of peroxide of lead and boiling the solution, manganese is oxidized to permanganic acid and determined in this form, as directed for the estimation of manganese in steel: III. 4.

GRAVIMETRIC METHOD.

For quantities over three per cent., the colorimetric method is as yet scarcely longer available*; a gravimetric determination is then resorted to. The usual practice is to separate the manganese from a nitric acid solution in presence of a large excess of strong nitric acid by precipitation with potassium chlorate as hydrated binoxide. The latter is separated by filtration, washed with strong nitric acid, and redissolved in sulphurous acid. The manganese in this solution is finally freed wholly from iron by a basic acetate precipitation. In the filtrate from the iron precipitate, manganese is precipitated in the form of ammonium manganese phosphate.

II. PIG IRON.

1. *Silicon.* 1 gram of metal is dissolved in a small covered porcelain dish in 10 c. c. of dilute sulphuric acid (1 vol. H_2So_4+3 vol. H_20) with the addition of an equal volume of water. The action of the acid is hastened by heating. When the evolution of hydrogen has ceased, the cover-glass is rinsed off into the dish, and the latter placed on the graphite-bath, where the contents of the dish are heated until dense white fumes of sulphuric anhydride form abundantly. The dish is removed from the bath, allowed to cool somewhat, and the residue treated with water. Heat and stirring are applied until all sulphate of iron has dissolved. The insoluble residue is filtered off, washed with water and dilute hydrochloric acid until free from iron, ignited, and weighed as SiO_2. If S represent the weight of metal taken for the determination, SiO_2 the weight of silica found, and Si the percentage of silicon, then is

*Experiments, with the object of determining the maximum percentage which may be estimated colorimetrically, are, however, in progress.

$$Si = \frac{SiO_2 \times 140}{S \times 3}$$

2. *Sulphur.* The method adopted for the estimation varies with the variety of iron and the accuracy required. For gray iron and "commercial" accuracy, the evolution-volumetric method is applied; for white iron and also gray varieties of pig iron, when the utmost accuracy is demanded, the aqua regia method is made use of.

EVOLUTION-VOLUMETRIC METHOD.

The details of the process are given below in the description of methods for the analysis of steel, q. v.: III. 2.

AQUA REGIA METHOD.

The sample—about 5 grams—is dissolved in concentrated nitric acid of 1.42 sp. gr., with the addition of a small quantity hydrochloric acid—a few cubic centimeters of concentrated acid at a time—and by the aid of heat, when necessary, to start the dissolving of the borings. When the action of the acid has ended, about two grams of sodium carbonate are added, and the solution is warmed until the escape of carbon dioxide has ceased. Silica is separated as usual by evaporation to dryness, solution of the residue in hydrochloric acid, and filtration. The slightly acid filtrate is diluted to 75-100 cc. for each gram of metal taken for the determination, and treated, while at a boiling temperature, with a hot solution of barium chloride in moderate excess. After the mixture has stood several hours, the precipitate of barium sulphate is collected on a Swedish washed filter, and washed as usual with hot water and dilute hydrochloric acid (1 vol. HCl, 1.20 sp. gr. + 20 vols. H_2O). Should the precipitate be contaminated with oxide of iron, a separation of the latter by fusion with sodium carbonate, etc., is undertaken after ignition.

4. *Manganese.* The same considerations and practice apply in the determination of manganese in pig iron as in the estimation of that element in steel: III. 4.

3. *Phosphorus.* The details of the method for the determination of phosphorus in pig iron are essentially the same as in the case of steel. 1.63 gram of borings are dissolved in 50 cc. of 20 per cent. nitric acid. The insoluble carbonaceous and siliceous matter is filtered off, and the filtrate—about 60 cc. in volume—is treated as directed under III. 3.

III. STEEL.

1. *Carbon.* In order to the determination of carbon in steel, the separation of the element is accomplished by decomposing the metal, as generally customary, by means of cupric potassium chloride. As well known, a residue containing the whole of the carbon remains after the action of the double chloride. By combustion in a stream of oxygen, the carbon of the residue is converted for weighing into carbon dioxide.

According to the amount of carbon present, 1–10 grams of steel are treated with the above mentioned solution—30–40 cc. for each gram of metal—of cupric potassium chloride which is made dissolving 1200 grams of a pure preparation of the salt in 3 liters of water and 50 cc. of concentrated hydrochloric acid, and filtration of the solution through ignited asbestos.

The mixture of chloride and steel borings is constantly stirred, warmed at first, and finally heated to about 100° C. until the metallic copper which separates in the reaction is redissolved. Sufficient dilute hydrochloric acid (1 vol. HCl, 1.20 sp. gr.+1 vol. H_2O) is added to dissolve the basic chlorides of iron and copper, which may separate out toward the end of the above operation, and keep them in solution during the subsequent filtration. This is effected by Dr. Blair's familiar device for the purpose, consisting, as need scarcely be added, of a platinum boat, with a finely perforated bottom, and a funnel of the same metal, into which the boat may be packed with asbestos tightly to allow of the use of the filter-pump. The packing is done by means of asbestos in the form of pulp such as is also used in forming a felt filter over the perforations in the boat. The pulp for the felt

may be conveniently made by heating asbestos wool to redness, cutting the fibers into short pieces with the scissors (a manipulation rendered much easier by the preparatory heating), and, after a second ignition, agitating with water.

When the carbonaceous residue has been collected in the boat, washed thoroughly with dilute hydrochloric acid and water, and dried at 100° C., it is ready for combustion.

The latter is carried out in a porcelain tube of the usual dimensions, heated in a ten-burner Bunsen combustion-furnace, and supplied with a slow stream of oxygen purified by passage over red-hot copper oxide and through absorbents for water and carbon dioxide, in the following order: Through potassium hydrate solution (1 KOH: 2 H_2O), and over granulated calcium chloride and soda-lime.

The combustion-tube, projecting four or five inches beyond the furnace at either end, is filled excepting the projecting ends and enough space in the rear for the reception of the boat, with coarsely granular copper oxide which is kept in place by short spiral rolls of copper gauze. Rubber stoppers at the rear and front ends of the tube connect, respectively, with the supply of oxygen and the apparatus for the purification and absorption of the carbon dioxide formed in the combustion-tube. The possible impurities which require removal are hydrochloric acid and chlorine. The gases issuing from the front end of the tube are, therefore, caused to pass first through a saturated solution of ferrous sulphate acidulated with a few drops of dilute sulphuric acid, where any chlorine in the mixture is converted into hydrochloric acid, and any of the latter substance in the gases is mainly absorbed. Should hydrochloric acid escape absorption in the ferrous sulphate solution, it is retained by the saturated solution of silver sulphate which follows. The gases leaving the silver solution are saturated with vapor of water. By passing them through concentrated sulphuric acid and over calcium chloride they are completely dried, and may enter the Geissler potash-bulbs

which immediately follow, and in which the absorption of their carbon dioxide takes place. The bulbs are filled with potassium hydrate solution (1 KOH : $2H_2O$); to prevent loss of moisture from the solution by the continuous passage of gas through the apparatus, the bulbs are fitted with a cover-tube, with ground joint, containing solid potassium hydrate.

Connected with the exit-end of the potash-bulbs, a 6-inch straight chloride of calcium tube, filled also with pieces of potassium hydrate, protects them against the possibility of the entrance of moisture and carbon dioxide from the atmosphere. It concludes the train of apparatus attached to the front end of the combustion-tube.

After the familiar preliminaries of introducing the boat with its carbonaceous residue, weighing and attaching the potash-bulbs, securing all connections, and starting a slow stream of oxygen through the apparatus, the combustion is begun by heating the front half of the porcelain tube to redness. The rest of the tube containing the boat is then gradually heated to the same temperature. For 15–25 minutes a red heat is maintained and the passage of oxygen continued. The oxygen is then cut off, and air from an independent drying and purifying apparatus—a duplicate of that described for use with oxygen—is drawn during 45–60 minutes slowly through the entire apparatus. By this manipulation all carbon oxide is brought into the potash-bulbs, and the latter filled with air. To insure a complete displacement of the oxygen in the potash-bulbs, after the main aspiration, air which has been freed from carbon dioxide is drawn for some minutes through the drying apparatus directly behind the bulbs, and the bulbs themselves.

The potash-apparatus is detached and allowed to stand 15–20 minutes in the balance-case where it had stood for at least the same length of time before the first weighing. The increase in weight is ascertained, and therefrom the percentage of carbon deduced according to the well-known formula.

2. *Sulphur.* The determination is effected by separating the element as cadmium sulphide and estimating the sulphur in the latter volumetrically with iodine solution.

The metal is dissolved in dilute hydrochloric acid; the gases evolved are passed into a strongly ammonical solution of cadmium chloride in which the sulphur, entering as sulphuretted hydrogen, is precipitated. The precipitate is filtered off, dissolved in a large volume of dilute hydrochloric acid, and the sulphuretted hydrogen again set free, measured as indicated above.

The solution of the sample is carried out in a 250 cc. Florence flask.

Into the neck of the flask is fitted a rubber stopper with three perforations. One of the latter receives the stem of a separating funnel with wide mouth and a bulb which should have a capacity of about 50 cc.; through another perforation passes the one-quarter inch *conduction-tube*, connecting the evolution-flask directly under the stopper with the *absorption-tube;* a third one-eighth inch tube, the *hydrogen-tube*, passes through the stopper to the bottom of the flask where it is drawn out to a point and bent upwards about one-eighth of an inch. Above the stopper it is connected with a supply of hydrogen.

The conduction-tube, which is in one piece, rises perpendicularly to about one-half inch from the stopper, bends away from the perpendicular about 60°, extending in this direction five or six inches, when it dips directly downward into the absorption-tube, a 10 in. × 1 in. lipped test-tube of stout glass. Between the first and second bends in the conduction-tube are blown two three-quarter inch bulbs.

The evolution-flask and absorption-tube are securely held in the required position by specially adapted racks—the flasks over Argand gas-burners—during the precipitation of the sulphur.

In carrying out a determination with the above apparatus,

3–5 grams of the sample are placed in the flask, and about 50 cc. of cadmium chloride solution (80 grams of cadmium chloride dissolved in 1500 cc. of conc. ammonia water and 2500 cc. of water) in the absorption-tube. Connections being made and the hydrogen-tube closed, 50 cc. of dilute hydrochloric acid (1 vol. HCl, 1.20 sp. gr. + 1 vol. H_2O) are gradually or at once, according to the probable rate of evolution of gas, run into the flask through the separating funnel, and a brisk generation of gas is maintained, if necessary, by the aid of heat. When the sample has dissolved, hydrogen is turned on in a slow stream, and the solution boiled until the bulbs of the conduction-tube become hot. The flame under the flask is then turned out, and the passing of hydrogen continued moderately 10–15 minutes.

The precipitated cadmium sulphide is next transferred to a rapid German filter. To this end, after disconnecting the absorption apparatus from the flask, the conduction-tube is withdrawn from the absorption-tube and laid aside, the adhering precipitate being before-hand washed down into the tube as completely as possible; the portion adhering firmly to the latter, unless it be considerable, is not removed to the filter, but left to be dissolved off, together with that remaining on the conduction-tube, at the final solution of the precipitate. After several washings the filter and precipitate are placed in a 600 cc. beaker. According to the quantity of precipitate, 200–400 cc. of water are poured over it, 3 cc. of starch solution (1 : 150) added, and the mixture stirred until the filter and precipitate are well disintegrated.

50 cc. of dilute hydrochloric acid (1 vol. HCl, 1.20 sp.gr. +1 vol. H_2O) are poured into the absorption-tube, and water is added to fill the tube to within about an inch of the top. The conduction-tube, which had been laid aside before the filtration, is quickly dipped into the diluted acid until its tip nearly touches the bottom, then raised and lowered in the fluid several times. By manipulating in this way, the precipitate left in the ab-

sorption and conduction tubes is almost instantly dissolved, the sulphuretted hydrogen formed absorbed in the surrounding fluid, and the comparatively strong solution of sulphuretted hydrogen, existing on their surfaces immediately after the contact of the precipitate with the acid, rinsed off. The contents of the absorption-tube are added to the water and precipitate in the beaker. The precipitate dissolves mainly at once and entirely on stirring. Without waiting until all cadmium sulphide has dissolved, the estimation of the sulphur is at once begun by titration of the liberated sulphuretted hydrogen with iodine solution.

The standard iodine solution is prepared by dissolving 1 gram of resublimed iodine in 50 cc. of an aqueous solution of potassium iodide ($1KI + 10H_2O$), and diluting to 1 liter. While pure reagents and careful manipulation insure a solution of the desired strength, the latter is nevertheless confirmed by direct experiment before the solution is used. For this purpose sodium thiosulphate is applied. A preparation of the salt of requisite purity may be made by recrystalization of the chemically pure preparation of the trade. A saturated, warm aqueous solution is prepared and cooled to nearly 0°C. with constant stirring. The compound separates under these circumstances as a minutely crystalline mass. By decantation and the use of the filter-pump, the mother-liquor may be almost completely removed. The still moist preparation is perfectly freed from water of solution between sheets of filter-paper.

3. *Phosphorus*, in order to its determination, is separated as ammonium phospho-molybdate and weighed as such.

1.63 gram of steel are dissolved in a covered beaker in 45 cc. of 20 per cent. nitric acid, the action of the acid being hastened by warming. When a perfect solution has been obtained and brought to the boiling-point, an excess of a saturated solution of potassium permanganate is added and the boiling continued for two or three minutes. While still boil-

ing, the mixture is treated with sufficient ferrous sulphate in saturated, slightly acified (5 cc. H_2SO_4 per liter) solution to dissolve the precipitated manganese binoxide resulting from the action of potassium permanganate on the original nitric acid solution of the metal. The binoxide disappears, leaving usually a clear solution. If it should not, recourse must be had to filtration for the removal of the "scale," etc., sometimes unavoidably weighed off at the beginning of the determination. A clear solution having been produced, about 15 cc. of water are added, and the contents of the beaker are again heated to boiling. The source of heat is removed, and the cover and walls of the beaker are rinsed down with water. The volume of the fluid at this stage of the operation should be about 60 cc. After stirring a few seconds, the temperature for precipitation, under 80°C., will exist in the solution. 45–50 cc. of molybdate solution are then added, and the mixture thoroughly and repeatedly stirred. The precipitant is prepared by dissolving 185 grams of pure ignited "molybdic acid" in 900 cc. of ammonia water (.96 sp. gr.), adding this solution to 2700 cc. of 32 per cent. nitric acid, and diluting the whole with water to 4000 cc. The supernutant fluid, when it has become clear, with as little disturbance of the precipitate as possible, is poured through a washed Swedish filter. The latter is washed twenty-five times with 1 per cent. (by vol.) nitric acid, when the precipitate is transferred to the filter, and the washing continued until the precipitate and filter are free from iron. The filter with its contents is dried for one hour at 100° C., and weighed between accurately-ground watch-glasses, the drying and weighing of the filter alone having before been conducted under similar conditions. The number expressing the weight of the precipitate in grams also represents the percentage of phosphorus.

4. *Manganese.* In the determination of manganese, the colorimetric method is used almost exclusively, the quantities encountered rarely exceeding three per cent. For higher per-

centages, as in the case of ores also, a gravimetric method is used. For the latter see I. 4, Grav. Method.

COLORIMETRIC METHOD.

The process consists in converting the manganese present into permanganic acid and deriving colorimetrically, by means of a solution of potassium permanganate* containing a known quantity of manganese, the amount of manganese in the permanganic acid obtained from a given weight of steel.

.1 gram of metal is dissolved in a 10 in. × 1 in. test-tube in 35–40 cc. of 32 per cent. nitric acid, and the solution heated to boiling over a small flame from a Bunsen burner. When the formation of nitrous fumes ceases, the heat is removed, and .2–.5 gram of peroxide of lead are added. Heat is again applied, and the mixture boiled for three or four minutes. The tube is then stood aside, closely covered and in the dark, in cold water until the excess of peroxide of lead has settled down. When clear, the acid solution above the peroxide of lead—now containing the manganese as permanganic acid—is decanted into a 50 cc. comparing tube, which is graduated to .5 cc., and is one of a set of three exactly similar tubes; the remaining two receive the solutions of potassium permanganate to be used in determining the quantity of manganese, in the form of permanganic acid, obtained by the process just described.

The permanganate solutions are prepared from a stock solution of such strength that 10 cc. of the same when diluted to 250 cc. will produce a solution of which 1 cubic centimeter contains .00001 gram of manganese as permanganic acid. In practice this dilute solution is called the *normal* standard. From the normal, others are prepared (by dilution with water in the comparing tubes) having a simple ratio—1:2, 1:3, 3:4, etc.—to the normal. All of these solutions are

*The use of potassium permanganate in this connection was, I believe, first suggested by Mr. B. B. Wright, formerly chemist to the Black Diamond Steel Works.

adjusted directly before use from the stock solution. The latter is made 1 liter at a time, and may, with proper precautions, be kept for several weeks without appreciable change.

Equipped with this solution and its derivatives, the procedure in estimating the quantity of manganese in the permanganic solution, yielded by a sample of steel under the conditions above detailed, is obvious and simple. In one of the comparing tubes are placed 30–40 cc. of a standard permanganate solution of lighter tiint than the permanganic solution. The latter is then diluted with water until the tints in both tnbes cannot be distinguished one from another, the examinaiton or "comparing" of the shades of color being carried out over a sheet of white paper in the diffuse light of a window. The ratio of the volumes of the two solutions is plainly equal to the ratio of the quantity of manganese contained in them. The volumes being read off from the graduated comparing tubes, and the quantity of manganese in one solution being known, the quantity in the other is readily calculated. If the normal permanganate be used, the number expressing the volume of the solution (in cc.) containing the unknown quantity of manganese divided by 100 is the required percentage when .1 gram of steel is taken for the determination ; if a standard of lighter tint be used, the volume must first be multiplied by the fraction showing its relation to the normal. For example, a volume of 35 cc. with the normal standard represents .35 per cent. manganese ; with a 3:4 standard, .26 per cent.

In the case of the higher percentages of manganese which may still be determined colorimetrically with convenience and accuracy, some modifications of the general method already given are advisable or necessary. It is advisable to weigh off for the determination at least one gram of borings that a representative result may be obtained from the sample. A solution in 32 per cent. nitric acid is prepared and diluted in a 500 cc. flask to the mark. Aliquot parts equivalent to .05—.10 gram are then taken for single determinations. After evapora-

tion to 5 to 10 cc., the transfer to a test-tube, and dilution to about 80 cc. with 32 per cent. nitric acid, the solution is ready for oxidation. Experiments thus far have shown that under the above conditions 10 to 20 minutes' boiling with .5 gram of peroxide suffices to oxidize at least 2.5 per cent. manganese in one-tenth of a gram. The test of complete oxidation is made the obtaining, within the limits of error, of the same result, whether one-tenth gram or half that quantity be used for the determination, the conditions being in each case in all other respects the same.

Further, after the decantation of the permanganic solution, a slightly varying quantity of the latter is left adhering to the tube and the residue of peroxide. When higher percentages are concerned, the quantity of manganese represented by the fluid residue is not inconsiderable, and cannot be neglected in accurate determinations, as in case of the lower percentages. The tube and residual peroxide should therefore be rinsed with a few cc. of water or 32 per cent. nitric acid. The rinsings are filtered through carefully washed asbestos into the decanted solution. The asbestos for the filtration is prepared by boiling with strong hydrochloric acid, washing with water, and ignition.

VI.

METHODS FOR THE ANALYSIS OF PIG IRON AND STEEL IN USE IN THE LABORATORY OF THE HAINSWORTH STEEL CO., PITTSBURGH.

BY S. M. RODGERS.

DETERMINATION OF SILICON IN PIG IRON AND STEEL.

Weigh .4702 grams pig iron, or 2 to 5 grams steel. Put into a 4 inch porcelain evaporating dish, add from 15 cc. to 60 cc. HCl of sp. gr. 1.20. Cover with a watch-glass and place on a moderately low light. When the action of the acid has ceased, remove the cover, rinsing it off carefully into the dish, and continue the evaporation to hard dryness, without decomposing the chloride of iron. Cool and moisten the residue with 5 cc. water (only in case of pig irons), and evaporate again to dryness at a temperature not exceeding 100° C., or at the lowest temperature necessary to expel all visible traces of moisture. Then add sufficient hot HCl (sp. gr. 1.10) to dissolve the iron, dilute with hot water to about 30 cc., and boil till the solution of the chloride of iron is complete. Filter through a 9 c. m. ashless filter, using moderate suction. Wash first with hot water, then with hot dilute HCl till all traces of iron are dissolved; then again with hot water till the precipitate is free from acid and chloride of iron. Place the filter in a deep platinum crucible over a low light and allow the paper to char slowly. Finally ignite at the highest temperature of the blast lamp, till the ash is white. Cool and weigh. If the precipitate does not burn perfectly white, or should contain traces of oxide of iron, add a few drops of hydrofluoric acid and 2 or 3 drops conc. H_2SO_4 and evaporate again (under the hood), and finally over the blast lamp. Cool, weigh and take the difference in the weights as the weight of SiO_2. Calculate in the usual manner.

DETERMINATION OF PHOSPHORUS IN PIG IRON AND STEEL.

Weigh 1.63 grams of pig iron or steel, place in a 4 inch dish and add 30 cc. HNO_3 (sp. gr. 1.20); cover with a watch glass, evaporate to dryness and bake at a temperature of about 200° C., from 30 to 60 minutes. Cool and dissolve in 15 cc. conc. HCl and evaporate again to dryness and bake 10 or 15 minutes longer. Cool and redissolve in HCl as before and add conc. $H\ NO_3$ from time to time, covering the solution with an inverted watch-glass a little smaller than the dish, and boil till all the HCl is destroyed. Dilute with an equal volume of hot water and filter into an eight ounce Erlenmeyer flask, using moderate suction. Now add conc. NH_4HO till the precipitated ferric hydrate *just dissolves*, leaving the solution a light amber color. Place a thermometer in the flask, heat to *exactly* 85° C., and add 40 cc. molybdic acid solution. Let stand five minutes, then cork the flask, wrap in a cloth and shake violently from three to five minutes. Set aside till the precipitate completely settles. Filter through a 9 c. m. Munktell's filter which has been previously washed and dried in an air bath at 110° C., and weighed between watch glasses to the nearest milligramme without swinging the beam. Wash the precipitate with dilute $H\ NO_3$, using moderate suction, and lastly with a few drops of 95 per cent. alcohol, and dry in an air bath at a temperature of 110° C. thirty minutes, or till all visible traces of moisture are gone. Place between watch glasses and weigh as before. The difference between the two weights in grams will be the per cent. of phosphorus.

The following method for phosphorus determination is both accurate and rapid:

Weigh into a platinum evaporating dish 1.63 grams of pig iron or high carbon steel. Add 30 cc. of 1.20 $H\ NO_3$, cover with an inverted watch glass a little smaller than the dish and evaporate to dryness. Heat cautiously over the blast lamp till all the nitrate of iron is decomposed. Then raise the heat to

a bright red for one or two minutes. Dissolve the residue in conc. HCl, evaporate off the excess of acid, add an equal amount of hot water, filter into an 8 oz. Erlenmeyer flask, add a few drops of hydrofluoric acid and two or 3 drops of conc. HNO_3 and boil one minute. Cool and add conc. NH_4HO drop by drop till a slight permanent precipitate is formed. Now add one or two cc. of 1.20 HCl, heat exactly to 85° C., and add 40 cc. of molybdic acid solution, shake rapidly for five minutes. Set aside till the precipitate settles and filter in a Gooch crucible, using strong suction. Wash the precipitate thoroughly with a 2 per cent. solution of nitric acid, once with water, and lastly with a few drops of 95 per cent. alcohol, and dry at 130° C. Cool in a desiccator and weigh.

In practice I use either a porcelain or platinum Gooch crucible with deep cap or lid, in which is placed an accurately fitting disk of filter paper. The crucible containing the disk is always kept in a desiccator and when wanted for use is carefully weighed. The disk is then moistened with water and placed under pressure to draw it closely to the bottom of the crucible. The solution containing the yellow precipitate is now rapidly filtered and washed as above directed. If the phosphorus is precipitated in a solution distinctly acid, which has been previously neutralized with NH_4HO, and not in one neutral or nearly so, the precipitate will not pass through the filter, no matter how strong the suction or rapid the filtration. The granular form of the precipitate, obtained in this manner, also facilitates both washing and drying.

In very low percentages of phosphorus, where great accuracy is required, the precipitate may be dissolved off the filter with dilute NH_4HO, the filter washed, dried and weighed as before, and the difference taken as the exact weight of the precipitate. When the weight of the yellow precipitate approximates one-tenth of a gram, the first weighing may be avoided, if the filter papers from which the disks are cut are carefully selected, in which case the weights of the disks will

not vary more than one or two milligrammes, a difference which may be neglected where extreme accuracy is not required. This method of manipulating obviates the inconvenience of drying and weighing the filter paper, also shortens the time required for drying. Under proper conditions the phosphorus seems to be as readily and completely precipitated in a hydrochloric acid solution as in a nitric solution, and is apparently less apt to be contaminated with traces of iron salts.

As a check upon these methods the molybdic acid process, as described by Prof. N. W. Lord in his "Notes on Metallurgical Analysis," page 22, gives the most satisfactory results.

DETERMINATION OF SULPHUR IN PIG IRON OR STEEL.

Evolution Method:—Weigh 5 grams of steel or iron into a 16 oz. ring-neck sulphur flask, and add 120 cc. HCl (sp. gr. 1.10), conducting the H_2S gas into an ammoniacal solution of cadmium chloride. After the violent action of the acid has ceased, place a low light under the flask, heat finally to boiling and continue the same till no more gas bubbles are carried over. Remove the flask and immediately add 200 cc. cold water and sufficient HCl to neutralize the excess of NH_4HO and dissolve the CdS. Add 5 cc. of fresh starch solution and titrate the amount of H_2S with standard iodine till the permanent blue color appears. In practice I make the iodine of such a strength that 1 cc. = .01 per cent. sulphur in 5 grams of metal, standardizing with bichromate of potassium and hyposulphite of sodium.

In some brands of pig iron I find the sulphur is more accurately determined by the use of 1.16 and 1.20 HCl, as these particular brands do not seem so readily soluble in 1.10 HCl.

Oxidation Method:—Weigh 5 grams of iron or steel into a 4 inch dish and add carefully 35 cc. concentrated HNO_3. Heat cautiously if the action is too slow. When the solution is almost complete, add 5 cc. conc. HCl and complete the

solution. Now add about 5 grams $KClO_3$ free from sulphur and evaporate to hard dryness, cool and dissolve the oxide of iron in the least quantity of HCl and again evaporate to dryness. Redissolve the residue in 30 cc. conc. HCl and evaporate almost to dryness and add 10 cc. dilute HCl. Dilute with an equal volume of hot water and filter. Wash with hot dilute HCl and finally with hot water till free from soluble salts, concentrate to about 75 cc., cool to 60° C. and add 5 cc. of a 10 per cent. solution of $BaCl_2$, stir and set aside till the precipitate settles perfectly clear, which requires usually about 2 to 3 hours. Filter through a small ashless filter, and wash with water containing 2 cc. HCl in 100. Suck the precipitate dry and place in a deep platinum crucible, heat at a low temperature till the paper is completely charred, and finally ignite at a dull cherry red till the precipitate is white, cool in a desiccator, weigh and calculate the amount of sulphur in the usual manner.

This method is used in determining high percentages of sulphur and also in checking the evolution process.

DETERMINATION OF MANGANESE IN PIG IRON AND STEEL.

Dissolve 5 grams of pig iron in 60 cc. HCl (sp. gr. 1.10) and evaporate just to hard dryness. Cool and redissolve in 10 cc. of the same acid, dilute with an equal volume of hot water and filter. Evaporate to one-half and add 50 cc. conc. HNO_3 and evaporate till all the HCl is expelled. Now add 75 cc. more conc. HNO_3, 5 grams $KClO_3$ and boil 20 minutes. Remove the beaker from the light and add 2 or 3 grams more $KClO_3$ and sufficient acid to keep the volume to about 50 cc. and continue the boiling for 15 minutes longer, or until the yellowish fumes are no longer given off. Cool and filter rapidly through asbestos, and wash two or three times with strong HNO_3, allowing each portion to run through before adding the next. Transfer the precipitate very carefully to the same beaker in which it was formed, rinsing the tube with a small quantity

of dilute HCl. Add a few crystals of oxalic acid, dilute with 25 cc. hot water and boil till all the MnO_2 is completely dissolved. Filter and wash thoroughly with hot water, and boil the filtrate a few minutes. Dilute to 250 cc.; add NH_4HO until a slight precipitate is permanently formed, and add one gram of ammonium acetate. Cover the beaker and boil rapidly till the iron separates. Filter and wash once or twice by decantation. Finally transfer the precipitate to the filter and wash once with hot water, letting the filtrate run into a 24 oz. beaker. Redissolve the precipitate with the least quantity of hot dilute HCl, letting the solution run into the same beaker in which it was precipitated, and make a second basic acetate separation in the same manner as the first. Test this precipitate with Na_2CO_3 on a platinum wire, and if not free from Mn make a third separation. Concentrate the combined filtrates to about 400 cc. and add carefully from 5 to 10 cc. of acetic acid, boil and add 5 to 10 grams $(NH_4)_3PO_4$ and stir till crystalline. Finally add 15 to 25 cc. conc. NH_4OH and continue the stirring until the precipitate is completely crystalline in its characteristic silky form. Remove from the light and let the precipitate completely settle. Then filter through an ashless filter, and wash thoroughly with water containing a few cc. of ammonia. Transfer the precipitate to a a deep platinum crucible and heat cautiously till the paper is completely charred, then increase the heat slowly till the highest temperature of the blast lamp is obtained, and continue the same till the precipitate is perfectly white and constant in weight. Cool in a desiccator, weigh and calculate the Mn in the usual manner.

In steels, dissolve 5 grams of drillings in 60 cc. 120 HNO_3, concentrate and precipitate the Mn with $KClO_3$ and proceed exactly as in pig iron. If the silicon should exceed 1-10 per cent, add a few drops of hydrofluoric acid before concentrating.

DETERMINATION OF CARBON IN IRON AND STEEL.

The determination of carbon is made according to the process described by Blair (Chemical Analysis of Iron, p. 138).

DETERMINATION OF NICKEL IN STEEL.

The method described by Blair is used (Chemical Analysis of Iron, p. 178).

VII.

METHODS FOR THE ANALYSIS OF ORES, PIG IRON AND STEEL IN USE IN THE LABORATORY OF THE HAINSWORTH STEEL CO., EDITH FURNACE DEPT., ALLEGHENY, PA.

BY R. G. JOHNSTON.

DETERMINATION OF SILICA IN IRON ORE.

Weigh out one gram of the finely ground ore, and transfer to a platinum crucible containing about ten grams of sodium carbonate. Fuse for about fifteen minutes, or until a quiet fusion is obtained. Allow the crucible to cool, and place it in a beaker containing about 40 cc. of water; add about 15 cc. of hydrochloric acid to dissolve the fused mass out of the crucible. Remove the crucible, rinsing it with a fine jet of water. Stand the beaker on the sand-bath, and evaporate its contents to dryness over night. Moisten the mass with a few cc. of hydrochloric acid, and add about 30 cc. of hot water. When all has dissolved, filter, wash well with hot water, dry, ignite, and weigh as SiO_2.

The filtrate may be used for determining either iron or alumina.

DETERMINATION OF IRON IN IRON ORE.

Weigh off .5 gram of the finely ground ore into a beaker without lip. Digest with 30 cc. of hydrochloric acid over night on the sand-bath. A solution of stannous chloride is now added drop by drop until the ferric chloride solution is

completely deoxidized. Dilute with about 100 cc. of hot water and add 30 cc. of a solution of mercuric chloride to oxidize an excess of stannous chloride.

Titrate with a standard solution of potassium bichromate, testing after each addition of the standard solution with a drop of potassium ferricyanide on a white plate for ferrous chloride.

$SnCl_2$ Solution.	$HgCl_2$ Solution.
80 grams of $SnCl_2$	50 grams of the salt
500 cc. of Water	1000 cc. of Water
500 " " HCl.	15 " " HCl.

The stannous chloride solution is made by dissolving 80 grams of the salt in 500 cc. of water and an equal volume of hydrochloric acid.

To prepare the mercuric chloride solution dissolve 50 grams of the compound in 1000 cc. of water acidified with 15 cc. of hydrochloric acid.

DETERMINATION OF PHOSPHORUS IN IRON ORES.

Weigh out 5 grams of the sample (10 grams if very low in phosphorus), and digest in a beaker with boiling hydrochloric acid for about one half hour. Filter, and fuse the residue with about 4 grams of sodium carbonate. Dissolve the fusion and evaporate the two solutions to dryness. Moisten with a few cc. of hydrochloric acid, take up with hot water, and filter from the silica. Combine the two filtrates, and evaporate to a syrup. Add about 30 cc. of nitric acid, sp.gr. 1.42, and evaporate a second time to get rid of the last traces of hydrochloric acid. Dilute the solution to about 50 cc , and add 15 cc. of strong ammonia, which will form a thick paste. Dissolve the latter in about 30 cc. of nitric acid, sp. gr. 1.20. Heat the solution to 80° C., and add 100 cc. of molybdic acid solution. Stir for a few minutes and allow the percipitate to settle. After about one hour, filter, and wash with a one per cent. solution of nitric acid. Dissolve the percipitate on the filter with a solution of ammonia (1 vol. of ammonia to 2 vols.

of water), allowing the solution to run into a small beaker containing a few crystals of citric acid and about 3 cc. of hydrochloric acid. The volume of the solution should now be about 100 cc. Add a few cc. of magnesia solution, stir well, and allow the mixture to stand over night. Filter and wash well with the above ammonia solution. Dry, ignite, and weigh. Dissolve the percipitate in the crucible in about 5 cc. of water and 3 cc. of nitric acid, and determine the weight of any residue insoluble in the acid. Deduct from the weight of the precipitate as obtained above. The difference is the weight of magnesium pyrophosphate derived from phosphate in the ore.

I have used this method for some three years and have always had good results.

DETERMINATION OF MANGANESE IN PIG IRON AND IRON ORE.

Weigh out 2 grams of the iron and dissolve in 40 cc. of nitric acid, 1.20 sp. gr. In a dish three and one-half inches in diameter, evaporate to a syrup or until a further evaporation would cause iron to separate out as basic nitrate. Dilute and wash into a half-biter flask; neutralize, and precipitate with oxide of zinc. Make the solution up to the mark, and shake well. Allow the precipitate to settle in a large beaker, decant off 250 cc. of the solution which correspond to one gram of iron, transfer to a flask, and heat to boiling. Titrate with a solution of potassium permanganate, shaking well after each addition of the standard solution. A pink coloration will show the end of the reaction.

For iron ores low in manganese, dissolve in HCl of 1.20 sp. gr. If a hematite, add a few drops of nitric acid of 1.20 sp. gr. Magnetite will require more oxidizing agent. In other respects proceed as above.

DETERMINATION OF SILICON IN PIG IRON.

Ford's method is used for this determination. See Blair's "Chemical Analysis of Iron," page 68.

DETERMINATION OF SULPHUR IN PIG IRON.

In determining sulphur, the evolution method is used. The sulphuretted hydrogen formed in dissolving the sample is absorbed in a solution of caustic soda (1 part of soda to 8 parts water), and, after acidification of the absorbent, titrated with iodine solution.

DETERMINATION OF PHOSPHORUS IN PIG IRON.

Emmerton's method as described by Blair, "Chem. Anal. of Iron," page 85, is made use of.

DETERMINATION OF MANGANESE IN PIG IRON.

The method of Volhard as modified by O. Textor is used for the estimation of manganese. The details have already been given in the description of methods for the analysis of ores.

VIII.

METHODS FOR THE ANALYSIS OF ORES, PIG IRON AND STEEL, IN USE IN THE LABORATORY OF THE CARNEGIE STEEL CO., EDGAR THOMSON STEEL WORKS AND FURNACES, BRADDOCK, PA.

BY C. B. MURRAY.

DETERMINATION OF SILICA IN IRON ORES.

One gram of the dried ore is fused with 12 to 15 grams of sodium carbonate in a large platinum crucible. After thorough fusion the crucible and contents are cooled in a 12-oz. beaker containing about 200 cc. of water. About the same volume of strong hydrochloric acid is now added and the fusion is dissolved. The solution is evaporated to dryness on a steam table, the residue taken up with 50 cc. hydrochloric acid diluted with water, the silica filtered, ignited and weighed.

In the case of manganese ores, 1 gram of the ore is dissolved in 50 cc. hydrochloric acid, boiled, filtered and the residue fused. The fusion is added to the original solution. Then proceed as above. This is to avoid the action of chlorine on the crucible.

DETERMINATION OF IRON IN ORES.

5 grams of the ore are dissolved in 50 cc. HCl. In case the residue left is not white the solution is filtered, the residue fused with Na_2Co_3, dissolved out in HCl, the iron precipitated as hydrate, dissolved in dilute HCl (1 : 1) and the solution added to main solution. As a rule there is no iron left in the residue, and then a fusion is not necessary.

To the hot solution of the ore stannous chloride is added from a burette drop by drop, stirring all the while, till the solution is colorless. Three drops in excess are then added. After allowing a few minutes for the stannous chloride to complete the reduction of any iron adhering to the silica, dilute to about 400 cc. with cold water, add *all at once* 20 cc. mercuric chloride solution and stir vigorously. Now add from a burette bichromate of potash enough to nearly oxidize all the iron. Place on a white tile several drops of the ferricyanide solution. Take out a drop of solution from the beaker and let it fall into a drop of the ferricyanide. Continue adding bichromate and testing as above till blue color is faint. Then take two drops for every test. Wait one-half minute at each test for color to develop. When no blue color appears at the end of one-half minute take burette reading, which gives directly the percentage of iron in the ore.

SOLUTIONS EMPLOYED.

The potassium dichromate solution contains 4.4 grams of the salt in 1 liter of water.

1 cc. corresponds to 0.005 gram iron, or to 1 per cent. when 0.5 gram of ore is employed.

The mercuric chloride solution contains 50 grams of the salt in 1 liter.

The stannous chloride solution contains 50 grams in one liter.

The potassium ferricyanide solution contains two or three pieces of the size of pin heads in 50 cc. of water. Prepare every other day.

DETERMINATION OF PHOSPHORUS IN ORES.

Dissolve 10 grams of the ore when the phosphorus is under 0.070 per cent. 5 grams when it is above 0.070 in 150 cc. HCl. Filter by suction. Treat the residue in the same manner as for silica and evaporate main solution to dryness on steam table. Take up main solution and fusion of

residue each with 100 cc. nitric acid. Heat on the sand-bath till all is in solution. Filter and unite the filtrates. To this fluid, which should not exceed 300 cc., add NH_4OH till the solution becomes a pasty mass. Add HNO_3 till the iron is redissolved and the solution becomes of an amber tint.

Heat to 70° C. and add 60 cc. of the mobybdate solution. Cork and shake thoroughly for five minutes. Let stand at a temperature of 40°–50° C. for an hour. Filter through a 12½ cm. filter. Wash thoroughly with a 2 per cent. HNO_3 solution. Dissolve the yellow precipitate on the filter in strong NH_4OH and let the solution run through into a 5-oz. beaker containing about 1 gram citric acid dissolved in 10 cc. strong HCl. After all the precipitate has been dissolved and run through the filter, stir the solution in the beaker and add 10 cc. magnesia mixture and fill up the beaker with strong ammonia. Stir a little and set in cold water till the solution is cold. Then stir vigorously until the precipitate comes down. Let stand over night. Filter through a 9 cm. filter. Wash thoroughly with dilute NH_4OH (1 : 3). Ignite, first at a low temperature, then at a higher. Weigh as $Mg_2P_2O_7$. Dissolve this weighed precipitate in dilute HNO_3 (1.20) heating crucible till all is in solution. Filter, ignite and weigh the residue, which is mainly silica. Subtract this weight from the first and the difference is pure $Mg_2P_2O_7$.

SOLUTIONS USED IN PHOSPHORUS DETERMINATIONS.

Mobybdic Acid Solution.—To each of two dishes which contain 1 lb. mobybdic acid each, add 1200 cc. of water. Stir into a paste and add 700 cc. NH_4OH (strong). Stir until dissolved. Transfer contents of each dish to a 4-liter flask and to each add 300 cc. strong HNO_3 and shake well.

Add the contents of each flask to a jar containing .9600 cc. water and 4000 cc. strong nitric acid. Shake mixture thoroughly. Test by heating to 85°C. If no mobybdic acid is precipitated it is ready for use.

Magnesia Mixture.=110 grams magnesium chloride and 140 grams ammonium chloride are dissolved in 700 cc. ammonia diluted with 1300 cc. water. The solution should stand at least a week before being used.

DETERMINATION OF MANGANESE IN ORES.

Dissolve 1 gram of the ore dried at 100° C. in 25 cc. strong hydrochloric acid. When all is in solution dilute with an equal bulk of water and filter. Wash twice with hot water. Ignite the residue till the filter paper is destroyed. Cool, add to the crucible two or three drops H_2SO_4 and a little HFl and evaporate to dryness to expel silica. Fuse the residue with about 3 grams Na_2CO_3. Dissolve fusion in the original filtrate from first solution, and evaporate this to dryness in the sand bath. Take up in 150 cc. strong nitric acid. Boil for about 20 minutes, and then add, a little at a time, 5 to 8 grams $KClO_3$. When enough has been added to oxidize all the manganese the solution will give a little puff and the green fumes will disappear. Now add about 1 gram $KClO_3$ more and boil the solution for two minutes. Cool and filter through a prepared asbestos filter or "plug." Wash beaker and plug twice with strong HNO_3. The filtrate should then be boiled and more $KClO_3$ added to see if all the manganese has been precipitated. The binoxide of manganese on the plug, together with the asbestos, is now returned into the same beaker in which the precipitation was made, and dissolved in 25 cc. HCl and boiled a few minutes. The asbestos is filtered off and a few cc. of H_2SO_4 are added to precipitate any barium which is generally found in manganese ores. Let stand about two hours. Now add NH_4OH till a faint precipitate appears, then 25 cc. of ammonium acetate solution. Boil for one minute, remove from the heat, and as soon as settled filter. Wash three times with hot water. Dissolve precipitate on filter in HCl (1 : 1) and let run into beaker in which first basic acetate was made. Make a second basic acetate separation just as the first. Combine

the filtrates and dilute to about 400 cc. Add 40 cc. ammonium phosphate solution and then acidulate with hydrochloric acid. Boil and add NH_4OH drop by drop with constant stirring until all the manganese is precipitated and the precipitate is in the well-known crystalline form. Let the solution cool, filter with suction, wash three times with hot water, ignite and weigh as $Mn_2P_2O_7$.

Solutions Employed.—Ammonium acetate solution. Dissolve 450 grams of the salt in 8 liters of water.

Ammonium phosphate solution. Dissolve 560 grams of the salt in 2500 cc. of water.

DETERMINATION OF MANGANESE IN MANGANIFEROUS IRON ORES.

Dissolve one gram of iron ore in 50 cc. HCl. Evaporate to dryness on steam bath. Take up in 20 cc. HNO_3. Evaporate to about 10 cc. Wash into a 500 cc. flask, dilute to about 200 cc. and add a solution of zinc oxide in water till all the iron is precipitated. Dilute to 500 cc., make acid, shake well, let settle and decant off 250 cc. into a flask. Boil for about 5 minutes. Titrate with a standard solution of permanganate of potash.

DETERMINATION OF SILICON IN PIG IRON.

Dissolve 1 gram of iron in 20 cc. strong HCl in a platinum dish. Evaporate to dryness over a bare flame. Heat for one minute after it is dry. Remove flame, add 10 cc. HCl and about 25 cc. water. Boil, filter, ignite and weigh as SiO_2.

DETERMINATION OF SULPHUR IN PIG IRON

Dissolve 5 grams in 100 cc. HCl (1 : 1) in a 500 cc. flask. Pass the gas evolved through two U tubes containing each 25 cc. NaOH solution. After the gas evolution has ceased heat the flask to boiling and boil till inlet tube to first U tube is hot. Remove the tube and draw off the NaOH solution from U tubes by means of stop-cock at bottom into a large porcelain dish. Dilute to 500 cc. Titrate with a standard solution of iodine.

SOLUTIONS EMPLOYED.

The sodium hydroxide solution contains 560 grams NaOH in 1700 cc. of water. The starch solution is prepared by dissolving 4 grams starch in a liter of boiling water and decanting the clear fluid for use.

The iodine solution is standardized by using a standard steel and also a "shot" sample. The factor varies considerably between the two. For pig iron drillings and steel the steel factor is used. For "shot" samples the shot factor.

DETERMINATION OF PHOSPHORUS IN PIG IRON.

Dissolve 1.63 grams in 25 cc. HNO_3 (1 20) in 4½ in. dish. Evaporate to dryness over lamp and bake for one-half hour. Take up in 20 cc. HCl and evaporate till the volume of the solution is about 4 cc. Add about 5 cc. HNO_3 and heat till red fumes cease to come off. Dilute twice with water and filter into an 8 oz. Erlenmeyer flask. Add NH_4OH till a paste is formed, then HNO_3 till the solution shows an amber color. Heat to 90° C. and add 50 cc. mobybdate solution. Shake for five minutes and let stand one-half hour. Filter and wash five times with 2 per cent. HNO_3 and twice with strong alcohol. The filters are then placed in a water-bath and heated one hour, removed and weighed in a "clip." Of course the filter papers should have been heated one hour and weighed previously. Since we started with 1.63 grams, calling the percentage of phosphorus in yellow precipitate 1.63, every milligram equals .001 per cent. phosphorus.

The solutions are the same as used in an ore analysis.

DETERMINATION OF MANGANESE IN PIG IRON.

1 gram of iron is dissolved in 25 cc. HNO_3 (1.20), evaporated to about 10 cc., then proceed as in case of manganese in manganiferous iron ores.

DETERMINATION OF CARBON IN STEEL.

In case of steels of over .50 per cent. carbon take 1 gram; for steels under .50 take 2 grams. Dissolve in

100 cc. in first case, or 150 cc. in second, of the double chloride of copper and potassium solution. Solution may be hastened by stirring and heating to about 80° C. After all is in solution filter into a platinum boat, wash four or five times with dilute HCl (1 : 1) and with hot water. For the combustion a platinum tube is used containing six inches of copper oxide held in place by platinum gauze.

The oxygen used in the combustion is purified by passage 1, through a bottle of KOH solution and 2, through a jar of solid potash, upon which a layer one inch deep of calcium chloride rests. A ten-burner Bunsen furnace is used.

Two burners are lighted under the copper oxide in the platinum tube. When this point is red hot all the burners are lighted and oxygen passed through for half an hour. The CO_2 is caught in a solution $Ba(OH)_2$ in a Meyer tube containing six bulbs. For carbon under 1 per cent. 25 cc. of a saturated solution of $Ba(OH)_2$ is sufficient. This amount will about fill four of the bulbs in the tube. At the end of half an hour the oxygen is shut off and air passed through the same train for 15 minutes. The Meyer bulb is then detached and the solution filtered through a 9 cm. filter using suction. By means of a rubber tube connected with the train a jet of air is forced into the funnel during filtering, keeping an atmosphere free from CO_2 surrounding the filter paper. The tube is easily washed clean. The filter paper with precipitated $BaCO_3$ is put into a platinum crucible and the crucible subjected to gentle heat until the filter paper is burnt, then placed in a muffle furnace and heated till white. Weighed as $BaCO_3$ and carbon calculated.

SOLUTIONS EMPLOYED.

Double Chloride of Copper and Potassium.—2250 grams of the double salt are dissolved in 6500 cc. water and one-half liter hydrochloric acid added.

The barium hydroxide solution contains 20 grams of the commercial baryta dissolved in one liter of water.

DETERMINATION OF SULPHUR IN STEEL.

5 grams of steel are dissolved in 100 cc. HCl (1 : 1). From this point on the method employed is the same as in the case of pig iron.

DETERMINATION OF PHOSPHORUS IN STEEL.

Dissolve 1.63 grams steel in 25 cc. HNO_3 (1.20), and proceed in the same manner as in the case of pig iron, except that it is not necessary to filter off graphite.

DETERMINATION OF MANGANESE IN STEEL.

Dissolve 1 gram in 25 cc. HNO_3 (1.20) and proceed as in case of pig iron.

DETERMINATION OF NICKEL IN STEEL.

The method given by Blair.

IX.

METHODS FOR THE ANALYSIS OF ORES, PIG IRON AND STEEL IN USE IN THE LABORATORY OF THE CLINTON IRON AND STEEL CO.

BY A. B. HARRISON.

DETERMINATION OF SILICA IN IRON ORES.

The ore is treated according to directions given on page 231, Blair's "Analysis of Iron."

DETERMINATION OF IRON IN IRON ORES.

The sample is dissolved in concentrated hydrochloric acid, the insoluble residue fused with sodium carbonate, and the fusion dissolved in dilute hydrochloric acid. The solution of ferric chloride obtained is reduced with stannous chloride, the excess of the latter being oxidized with bichloride of mercury. The reduced iron solution is titrated with potassium bichromate.

DETERMINATION OF PHOSPHORUS IN ORES.

The sample is dissolved in hydrochloric acid, the insoluble residue fused with sodium carbonate, and the fusion dissolved in dilute sulphuric acid. The filtrate from the insoluble residue and the filtrate from the solution of its fusion are combined, precipitated with ammonia, .96 sp. gr., and the precipitate dissolved in nitric acid of 1.13 sp. gr. The determination is then proceeded with as in the case of steel.

DETERMINATION OF MANGANESE IN ORES.

See the method described for determination of manganese in pig iron.

DETERMINATION OF SILICON IN PIG IRON.

Drown's method somewhat modified is used. Dissolve .4667 gram of drillings in "silicon mixture" in a covered porcelain dish, and evaporate the solution to dryness without

removing the cover. When the dish is sufficiently cool wash off the watch-glass into the dish, and rinse down the sides of the dish with hot dilute hydrochloric acid (1:1) until the volume of the fluid is 50 cc. Boil until all iron salts are dissolved, filter with the aid of suction, and wash alternately with hot water and dilute hydrochloric acid until all iron is washed out. Burn and weigh. Ashless filters being used, no calculation beyond "pointing off" will be necessary, as can readily be seen.

The silicon mixture is made as follows: Mix 1500 cc. of water, 500 cc. nitric acid of 1.4 sp. gr., and 150 cc. of sulphuric acid of 1.84 sp. gr.

DETERMINATION OF SULPHUR IN PIG IRON.

The determination of sulphur is carried out according to the "iodine method" as given in Blair's "Analysis of Iron," 1891, pages 68–71. In this form the method is the iodine method as modified by Mr. E. T. Wood.

DETERMINATION OF PHOSPHORUS IN PIG IRON.

For this purpose I use Emmerton's method as described by Dr. Dudley.

DETERMINATION OF MANGANESE IN PIG IRON.

Manganese is determined according to a modification of Volhard's method. One gram of drillings is dissolved in 100 cc. of silicon mixture in a porcelain evaporating dish. After solution 5 cc. of concentrated hydrochloric acid are added, and the contents of dish evaporated to dryness. The cover of the dish is washed off with hot water and the residue taken up with 100 cc. of water. Boil till all iron salts are dissolved. Transfer the solution without filtering to a 1,000 cc. flask, and dilute with water to 300 cc. Bring the contents of the flask to boiling, and add pure zinc oxide suspended in water till all iron is precipitated and zinc oxide is present in slight excess. Titrate the contents of the flask while boiling hot and without filtering with potassium permanganate solution.

DETERMINATION OF SILICON, SULPHUR, PHOSPHORUS, MANGANESE AND NICKEL IN STEEL.

Silicon is determined as described in Blair's "Analysis of Iron," 1891, page 72.

Sulphur is estimated by the method given for pig iron. The aqua regia method is used for checking.

Phosphorus I determine as in pig iron. Results are checked by the "magnesia method."

For nickel determinations the method of A. T. Eastwick is used. See Proceedings of the Engineers' Society of Western Pennsylvania, vol. IX, page 170.

Manganese is determined by the method described for pig iron.

X.

METHODS FOR THE ANALYSIS OF IRON ORES, PIG IRON AND STEEL IN USE AT THE LABORATORY OF THE ISABELLA FURNACE CO., ETNA, PA.

BY F. G. BRINKER.

DETERMINATION OF SILICA IN IRON ORES.

Dissolve 1 gram finely powdered ore in hydrochloric acid, dilute, filter, wash and fuse residue with a mixture of sodium and potassium carbonates. The fusion is dissolved in a beaker in hydrochloric acid. Evaporate to dryness and bake. Dissolve in hydrochloric acid, dilute the solution, filter, wash the residue with hot water, dilute hydrochloric acid and again with hot water. Burn and weigh.

DETERMINATION OF IRON IN IRON ORES.

Dissolve 1 gram ore, finely pulverized, in a flask in 40 cc. hydrochloric acid, at a gentle heat. Add 1 gram of potassium chlorate. Place a funnel in the neck of the flask and boil gently till chlorine is expelled. Dilute to 50 cc., heat nearly to boiling, and deoxidize with a solution of stannous chloride measured by means of a burette. Cool, and titrate back the excess of stannous chloride with a solution of Iodine.

If greater accuracy be required filter and fuse the insoluble residue, dissolve in acid and add to the main solution before deoxidizing.

In preparing the standard iron solution, I use fine iron wire and treat it as above described. The first factor is found by standardizing the stannous chloride and iodine solutions. Take 2 cc. of stannous chloride solution, dilute, add a little starch solution and titrate with iodine solution. Divide

the number of cc. of iodine into the number of cc. of stannous chloride. Multiply the number of cc. of iodine used to titrate back the excess of stannous chloride used by this factor, and subtract from the total volume of stannous chloride used for the reduction. The second factor is found by dividing the number of cc. of stannous chloride, used for the standard after the excess has been subtracted, into the weight of pure iron in the iron taken.

Multiply the number of cc. of $SnCl_2$ by this and by 100. This gives the per cent. of iron in the sample.

Solutions Used.

Stannous chloride solution ; dissolve 60 grams of crystals in 125 cc. hydrochloric acid and 125 cc. water. To this solution there are added 650 cc. hydrochloric acid and 1650 cc. water.

Iodine solution ; this contains 8 grams iodine dissolved in KI solution and diluted to 1 litir.

I use also the permanganate method as described by Blair (Chemical Analysis of Iron), deoxidizing by zinc. When titanium is present, I use acid ammonium sulphate.

DETERMINATION OF MANGANESE IN IRON ORES AND PIG IRON.

I use Williams' method and also Vohlhard's method as described in Blair's Chemical Analysis of Iron, second edition.

DETERMINATION OF PHOSPHORUS IN IRON ORE.

I use the molybdate-magnesia method as described by Blair.

DETERMINATION OF SILICON IN PIG IRON.

Dissolve .9333 gram of drillings in a casserole in hydrochloric acid, and evaporate to dryness, Cool and take up with hydrochloric acid, heating the mixture to boiling. Dilute, filter, wash with dilute hydrochloric acid, and finally with hot water. Ignite cautiously until the filter has been burned off. The ignition is then continued for 15 minutes at the

highest heat of a gas blast-lamp. Cool and weigh. The weight of the silica found divided by 2 and multiplied by 100 gives the percentage of silicon.

DETERMINATION OF PHOSPHORUS IN PIG IRON.

Weigh 1.63 grams of well-mixed borings into a 500 cc. beaker and add cautiously 35 cc. nitric acid of 1.2 sp. gr. Boil down to dryness, bake on a hot plate at 200° C. for 30 minutes. Redissolve in hydrochloric acid. Add 35 cc. of concentrated nitric acid and evaporate until the volume of the fluid is reduced to about 15 cc. Remove from the hot plate, dilute with hot water, filter, and to the filtrate add ammonia until a precipitate forms which does not disappear on stirring. The neutralized solution is treated with 3 cc. of concentrated nitric acid, which should suffice to redissolve the precipitate and give a clear, amber-colored liquid, not red in tint. The solution is then heated to about 70° C., the molybdate solution added, and the mixture shaken for five minutes. Let the precipitate settle, collect it on a weighed filter, and wash with water containing 2 per cent. of nitric acid. Dry in the air-bath at 120° C. for 30 minutes after all visible moisture has disappeared, and weigh.

XI.

METHODS FOR THE ANALYSIS OF ORE, PIG IRON AND STEEL, IN USE IN THE LABORATORY OF THE SHENANGO VALLEY STEEL CO., NEW CASTLE, PA.

BY WARREN R. CLIFTON.

DETERMINATION OF SILICA AND IRON IN ORES.

Weigh one gram of the sample into a No. 2 beaker, add 25 cc. of strong hydrochloric acid, cover with a watch-glass, and digest at a temperature just short of boiling until the ore is decomposed; dilute with 25 cc. of water and filter into a No. 4 beaker. The residue is then burned and fused with sodium carbonate, the fusion dissolved in the filtrate from the residue, and the whole allowed to go to hard dryness. Redissolve the mass in about 15 cc. of strong hydrochloric acid, dilute, filter into a 300 cc. flask, and wash the residue 3 or 4 times with hot water, ignite, and weigh as SiO_2. In the filtrate the iron is deoxidized by granulated zinc and determined by titration with a standard bichromate solution; the addition of the standard is continued until a drop of the iron solution added to a drop of potassium ferricyanide solution no longer produces a blue coloration on standing one-half minute. The number of cc. of bichromate solution used muliplied by one hundred times the value of 1 cc. in iron gives the per centage of iron.

Bichromate Potash Solution.—Dissolve 17.570 grams of the fused salt in water, dilute to 2000 cc. and standardize with iron wire.

DETERMINATION OF PHOSPHORUS IN ORES.

Digest 5 grams of the samples dried at 100° C. in a No. 2 beaker covered by a watch-glass in 50 cc. of strong hydro-

chloric acid. When the ore appears to be perfectly decomposed, dilute, and filter into a No. 5 beaker. The residue is burned and fused with sodium carbonate, the fusion dissolved in hot water, the solution acidified with strong hydrochloric acid; and added to the original filtrate; the combined solutions allowed to go to hard dryness on the hot plate. The mass is then moistened with a little hydrochloric acid, diluted with a sufficient amount of water to dissolve the sodium salt, and filtered into a 400 cc. Erlenmeyer flask. The process is then carried on as in case of steel.

DETERMINATION OF MANGANESE IN IRON ORES.

Two grams are dissolved and further treated in the same manner as for phosphorus and the solution filtered into a 500 cc. flask. The solution is neutralized with ammonia until a slight permanate precipitate forms. Redissolve this with a few drops of hydrochloric acid, and add ammonium carbonate drop by drop, until a faint preciptate is formed. Add about 4 grams of sodium acetate, boil one minute, and allow the precipitate to settle. Filter into a 500 cc. flask, and wash 2 or 3 times with hot water. The precipitate is washed back into the same flask in which the precipitation was made, and dissolved in the least possible quantity of hydrochloric acid. The precipitation is repeated exactly as before. Unite the filtrates and proceed as in the case of steel.

DETERMINATION OF SILICON IN PIG IRON.

Twice the factor-weight—.9340 gram of drillings—is weighed off into a No. 5 beaker. Add 50 cc. of water, and then pour into the mixture 20 cc. of sulphuric acid, 1.85 sp. gr. directing the acid to the center of the beaker. Evaporate until copious fumes of sulphuric anhydride are given off. Cool the beaker over a cold blast jet. Add 100 cc. of water and 4 or 5 cc. of hydrochloric acid. Boil until all sulphate of iron has dissolved, filter hot, wash at first with dilute

hydrochloric acid (1 of acid to 1 of water), and then with hot water; ignite, and weigh. One-half the weight in decimilligrams is the per cent. of silicon in hundreths.

DETERMINATION OF SULPHUR IN IRON AND STEEL.

Dissolve 5 grams of drillings in a No. 5 beaker, covered by a watch-glass, in 50 cc. of strong nitric acid. When the violent action has ceased, add 15 cc. of strong hydrochloric acid, and, when solution is complete, about one-half gram of carbonate soda; and evaporate the solution to hard dryness. Remove the beaker from the heat; when cold add 40 cc. of strong hydrochloric acid, and heat gently at first, until the oxide of iron is dissolved; evaporate again to syrup, and, if any ferric chloride separates, add a few drops of strong hydrochloric acid; dilute, and filter, washing with the least possible amount of dilute hydrochloric acid to remove the last trace of iron. Heat the filtrate, which should have a volume of about 400 cc., to boiling, add 5 cc. of a saturated solution of barium chloride, and allow to stand at about 40° C. over night. Filter through a 9 cm., Munktell's No. 1 filter; wash with a little dilute hydrochloric acid (1 of acid to 1 of water), and finally with hot water; dry, ignite, and weigh as $BaSO_4$.

DETERMINATION OF SULPHUR IN PIG IRON AND STEEL.

Evolution Method.—Place 3 grams of drillings in a dry 500 cc. flask provided with a double perforated rubber stopper; the stopper carries a one bulb thistle-tube, and a small piece of glass tubing bent at right angles; the latter is connected by a short piece of rubber tubing to a glass tube running to the bottom of an intervening bottle; the exit-tube of the bottle is connected by rubber tubing to a delivery tube, also bent at right angles, reaching to the bottom of a one-inch by eight-inch specimen-tube. Connected by rubber stopper and delivery-tube with this is a second specimen-tube. The whole apparatus is suitably supported. Dilute 15 cc. of an ammonical cadmium chloride solution to 100 cc. with cold water, and pour one-

half into each of the specimen tubes. About 100 cc. of boiling water is added to the 500 cc. flask, and the flask connected with the apparatus above described. Introduce, through the thistle-tube, 50 cc. of strong hydrochloric acid. When the sample has dissolved, boil the solution until the steam reaches the first specimen-tube, then disconnect at the latter, turn out the light, and allow the flask to draw back the acid and water which has distilled into the intervening bottle. Transfer the contents of the specimen-tubes to a 400 cc. Erlenmeyer flask, rinsing the tubes with a little hydrochloric acid and water. Now add a few cc. of starch solution, acidulate with strong hydrochloric acid, and immediately run in the iodine solution, from a burette, agitating the contents of the flask at the same time, until the proper blue color is obtained. The volume in cc. of iodine solution used multiplied by the value of 1 cc. is the percentage of sulphur in the sample.

Cadmium Chloride Solution.—Dissolve 120 grams of cadmium chloride in 1500 cc. of water, add 600 cc. of strong ammonia.

Iodine Solution.—Weigh out into a half-litre flask 8 grams of iodine, and 20 grams of potassium iodide. Add about 100 cc. of water. Allow to stand over night and dilute to 2000 cc. The solution is standardized with an iron of known sulphur-contents. The known percentage of sulphur divided by the number of cc. of solution required is the strength of the iodine solution.

DETERMINATION OF PHOSPHORUS IN PIG IRON AND STEEL.

Three grams of drillings are dissolved in a No. 5 beaker in 40 cc. of 1.20 sp. gr. nitric acid and the solution evaporated to hard dryness. Allow the beaker to cool, dissolve the precipitate in 30 cc. of strong hydrochloric acid, dilute with cold water, filter into a 400 cc. Erlenmeyer flask, and wash the filter with cold water. Add 10 cc. of strong ammonia and agitate the mixture until the precipitate formed is all dissolved. The solution is heated or cooled to 60° C., and 50 cc. of

molybdate solution are added by aid of a pipette; the flask is shaken for two or three minutes and then allowed to stand till the precipitate has settled. Filter, collect the precipitate on a 7 cm., S. & S. No. 589 filter, and wash with dilute molybdate solution—water and 5 per cent. of its volume of the above. Pour 3 or 4 cc. ammonia on the precipitate, stir it up with a fine jet of water and allow the solution to run into the flask in which the precipitation was made. Add drop by drop enough strong hydrochloric acid to cause the separation of the yellow precipitate, and then ammonia until it redissolves. Pour the solution back through the filter, allowing it to run into a 120 cc. Erlenmeyer flask, and wash two or three times with cold water. To the cold solution add very slowly 10 cc. of magnesia-mixture, agitating constantly, and, after the precipitant is all in, 5 cc. of strong ammonia. Shake vigorously. Stand the flask in cold water for about one hour; filter on a 7 cm., S. & S. No. 589 paper, and wash with 5 per cent. ammonia. Ignite over the blast-lamp at a low heat, and weigh as $Mg_2P_2O_7$.

Molybdate Solution.—Dissolve 100 grams of molybdic acid in 450 cc of strong ammonia. Pour 1,250 cc. of 1.20 sp. gr. nitric acid into a 2,500 cc. bottle, and place the bottle in a pail of cold water. Now add, in small portions, the molybdic acid and ammonia, taking about 30 minutes in the operation. The mixture is kept in a warm place for 48 hours and is then ready for use.

Magnesia Mixture.—Dissolve 280 grams of ammonium chloride together with 110 grams of magnesium chloride in 1,300 cc. water, and add 700 cc. of strong ammonia. Allow the preparation to stand four or five days before using.

DETERMINATION OF MANGANESE IN STEEL AND PIG IRON.

Dissolve 3 grams of drillings in a No. 5 beaker in 50 cc. of 1.20 sp. gr. nitric acid, evaporate until the solution is almost of a syrupy consistence, add 100 cc. of strong nitric acid, heat the solution to boiling, and while boiling add 5 grams of

potassium chlorate in small portions. Continue the boiling for 10 minutes. Cool the solution rapidly by standing the beaker in a pan of cold water; filter by aid of a pump through purified asbestos supported by a small piece of pumice stone in the stem of the filtering tube; wash 2 or 3 times with strong nitric acid. Transfer the precipitate, with the asbestos filter, to the beaker in which the precipitation was made. The filtering tube is washed off with water and a little hydrochloric acid; add about 5 cc. of hydrochloric acid, and agitate the contents of the beaker until the asbestos is all suspended. Heat the mixture till the precipitate is dissolved; filter from the asbestos into a No. 2 beaker, and wash with hot water. To the filtrate add enough ammonium acetate to precipitate the last traces of iron, boil and filter into a 400 cc. Erlenmeyer flask.

DETERMINATION OF MANGANESE IN STEEL.

One-tenth of a gram of each sample and of the standard is measured off into one-inch by eight-inch test-tubes. Pour into each test-tube 15 cc. of 1.20 sp. gr. nitric acid. When the violent action has ceased boil over an Argand burner till nitrous fumes are driven off. While boiling, add about five-tenths of a gram of peroxide of lead, and boil each sample and the standard exactly one minute. The tubes thus filled are immediately placed in cold water and set aside in a dark place. When cool, and the excess of peroxide has settled out leaving the supernatant fluid perfectly clear, the standard solution is decanted into one of the comparing tubes. The solution is then diluted with water to as many cc. as the standard contains hundredths of one per cent. of manganese, and mixed thoroughly with the water. The test sample is decanted in the same manner, and diluted with cold water until it has the same shade as the standard solution. The reading in cc. represents the percentage of manganese in hundredths.

DETERMINATION OF MANGANESE IN PIG IRON.

It is preferable in this case to dissolve one gram. To the filtrate add an excess of strong ammonia, and then, with a

vigorous shake, a few cc. of bromine. Heat gradually to boiling, allow the precipitate to settle, filter and wash with cold water. The washing of the precipitate is easily accomplished by means of cold water, there being no fixed alkali present. Ignite over a blast lamp at a low heat and weigh as Mn_3O_4.

In the case of pig iron, dissolve in 50 cc. of dilute hydrochloric acid. Dilute and filter into a No. 5 beaker, evaporate down to nearly a syrup, being careful not to heat too hot. Redissolve in 50 cc. of strong nitric acid, and evaporate to total expulsion of hydrochloric acid. Add 100 cc. of strong nitric acid, heat to boiling, add 5 grams of potassium chlorate, and proceed as described for steel.

DETERMINATION OF NICKEL IN STEEL.

Dissolve one gram of drillings in a No. 4 beaker in 25 cc. of 1.20 sp. gr. nitric acid and evaporate to hard dryness. Redissolve in 15 cc. of strong hydrochloric acid and separate the iron exactly as directed in the determination of manganese in ores. Unite the filtrates and boil down until their volume is reduced to about 300 cc. Acidulate with a few drops of acetic acid, heat to boiling and pass hydrogen sulphide till the solution smells strongly of the gas. Boil a few minutes until the precipitate has a flocculent appearance. Filter and wash with hot water, ignite the filter and precipitate, and transfer them to a No. 2 beaker. Dissolve in 3 or 4 cc. of strong hydrochloric acid with a few drops of strong nitric acid, evaporate to dryness, redissolve in a few drops of strong hydrochloric acid, dilute to about 100 cc., heat to boiling and pass hydrogen sulphide through the solution, let the precipitate subside, filter if necessary, wash with hot water, and if desired burn and weigh as Cn_2S. To the filtrate add an excess of ammonia, pass hydrogen sulphide, allow the precipitate to settle, filter, wash, ignite in a porcelain crucible, and weigh as NiO.

XII.

METHODS FOR THE ANALYSIS OF IRON AND STEEL IN USE AT THE LABORATORY OF THE PENNSYLVANIA RAILROAD COMPANY, ALTOONA, PENN'A.

BY C. B. DUDLEY AND F. N. PEASE.*

"Method of Determining Carbon in Iron and Steel." By C. B. Dudley and F. N. Pease. *American Engineer and Railroad Journal*, July, 1893, p. 347.

"Method of Determining Carbon in Iron and Steel." By C. B. Dudley and F. N. Pease. *Am. Eng. & R. R. Journal*, August, 1893, p. 391.

"The need of Standard Methods for the Analysis of Iron and Steel with some Proposed Standard Methods." By C. B. Dudley and F. N. Pease. *Journal American Chemical Society*, September, 1893.

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*In publishing in the Proceedings of the Chemical Section of the Engineers' Society of W. Penn'a., the methods of chemical analysis in use at the different iron and steel works laboratories, it has been the practice heretofore, to print the methods in detail as described by the senders. In the case of the methods of Dr. C. B. Dudley and Mr. F. N. Pease, of the Pennsylvania Railroad Laboratory at Altoona, an exception has been made. Dr. Dudley, in charge of the Altoona Laboratory, has kindly placed at the disposal of the Committee, the details of the admirable methods so fully and clearly described in the publications of the Pennsylvania Railroad Laboratory. These methods have, however, been repeatedly reproduced in technical journals, and in the transaction of various scientific societies, and they are already so well known to chemists that a detailed account of them seems hardly necessary. In place of complete details, therefore, a list of references to the papers of Dr. Dudley and Mr. Pease is here given.

Some of the papers do not deal with single methods of determination of the constituents of iron and steel, but are of such general interest that it seems eminently proper that they should be included among the papers upon methods.

"Method of Determining Sulphur in Steel." By C. B. Dudley and F. N. Pease. *Am. Eng. & R. R. Journal*, Sep., 1893, p. 443.

"Standard Methods for the Analysis of Iron and Steel." By C. B. Dudley, Ph. D., Proc. Chemical Section Eng. Soc., W. Pa., Oct., 1893.

"Method of Determining Sulphur in Pig and Wrought Iron." By C. B. Dudley and F. N. Pease. *Am. Eng. & R. R. Journal*, Dec., 1893, p. 579.

"Method of Determining Manganese in Steel." By C. B. Dudley and F. N. Pease. *Am. Eng. & R. R. Journal*, April, 1894, p. 176.

"An Attempt to find the Amount of Phosphorus in Three Samples of Steel." By C. B. Dudley and F. N. Pease. *Journal American Chemical Society*, April, 1894.

"On Some Points in the Determination of Phosphorus in Steel by the Volumetric Method." By C. B. Dudley and F. N. Pease. *Journal American Chemical Society*, April, 1894.

"Method of Determining Silicon in Steel." By C. B. Dudley and F. N. Pease. *Am. Eng. & R. R. Journal*, July, 1894, p. 321.

"Method of Determining Phosphorus in Steels." By C. B. Dudley and F. N. Pease. Separate paper published by the P. R. R. Co.

The methods above mentioned for the determination of carbon and of sulphur in steel are also published and distributed by the Pennsylvania Railroad Company.

XIII.

METHODS FOR THE ANALYSIS OF ORES, PIG IRON, AND STEEL, IN USE IN THE LABORATORY OF McINTOSH, HEMPHILL & CO., PITTSBURGH, PA.

BY J. P. M'KELVEY.

DETERMINATION OF SILICA IN IRON ORES.

Fuse with sodium carbonate, dissolve in hydrochloric acid and evaporate to dryness, moisten the residue with hydrochloric acid, take up with water, filter, wash, ignite and weigh.

DETERMINATION OF IRON IN IRON ORES.

The filtrate from the silica serves for the iron determination. Reduce in a 600 cc. Erlenmeyer flask with tested zinc, and titrate with bichromate as usual, using potassium ferricyanide as an indicator.

DETERMINATION OF MANGANESE IN IRON ORES.

Dissolve one gram of ore in hydrochloric acid and evaporate to dryness. Redissolve in 50 cc. of nitric acid (1.42), and proceed as in Ford's method.

DETERMINATION OF PHOSPHORUS IN IRON ORES.

Dissolve 5-10 grams of ore in hydrochloric acid and evaporate to dryness. Take up in a small amount of hydrochloric acid, dilute, filter and proceed as in the acetate method, separating arsenic by sulphurated hydrogen.

DETERMINATION OF SILICON IN PIG IRON.

Dissolve one gram of drillings in 30 cc. of dilute hydrochloric acid and evaporate to dryness. Moisten the residue with hydrochloric acid, dilute, filter, wash, ignite and weigh.

DETERMINATION OF SULPHUR IN PIG IRON.

As given in Blair's "Analysis of Iron," page 65, under the heading "By Oxidation and Solution."

DETERMINATION OF PHOSPHORUS IN PIG IRON.

The Acetate method is used.

DETERMINATION OF MANGANESE IN PIG IRON.

This determination is made by the color method as given in Blair's "Analysis of Iron," with the exception that after solution of the drillings and before diluting to 100 cc., the solution is filtered.

DETERMINATION OF SULPHUR, PHOSPHORUS, MANGANESE AND NICKEL IN STEEL.

Sulphur and phosphorus are determined according to the methods already detailed for pig iron; manganese by the colorimetric method described in Blair's "Analysis of Iron;" for nickel determination see the above work, page 178.

XIV.

METHODS FOR THE ANALYSIS OF IRON ORE, PIG IRON AND STEEL, IN USE IN THE LABORATORY OF THE W. DEWEES WOOD COMPANY, McKEESPORT, PA.

BY THEO. TONNELE AND R. B. CARNAHAN, JR.

IRON ORES.

The sample, which has been put through a 100-mesh seive, is dried thoroughly at 100° C. just previous to analysis.

DETERMINATION OF SILICA IN IRON ORES.

Fuse 1 gram of the ore with 5 grams sodium carbonate and 25 grams potassium nitrate in a platinum crucible. Acidify with hydrochloric acid and evaporate to dryness. Redissolve in sufficient water and hydrochloric acid, filter, wash with dilute hydrochloric acid (sp. gr. 1.1) and hot water, burn and weigh. Treat the ignited residue in the usual way with hydrofluoric acid and a few drops of sulphuric acid; the loss in weight represents the quantity of silica in the ore.

DETERMINATION OF IRON IN ORES.

Dissolve 0.75 gram in concentrated hydrochloric acid, heating on the steam-bath over night. De-oxidize the ferric iron of the solution with stannous chloride, adding the latter gradually. When the solution is entirely colorless, cool somewhat, and then add 10 cc. of mercuric chloride solution. Titrate in the regular way with standard potassium bichromate, using a very dilute solution of potassium ferricyanide to determine the end reaction.

Solutions.—The mercuric chloride is a saturated aqueous solution. The stannous chloride solution contains 150 grams

of the salt dissolved in 1000 cc. of hydrochloric acid, (1.1 sp. gr.) To prepare the standard bichromate, dissolve 7 grams of the salt in 1000 cc. of water, and dilute so that 1 cc. is equivalent to .0075 gram of iron. The solution is standardized from a steel of known composition.

DETERMINATION OF PHOSPHORUS IN ORES.

From 3 to 5 grams of ore (according to the percentage of phosphorus) are dissolved in strong hydrochloric acid, and the solution evaporated to dryness; the residue is redissolved in a few cc. of strong hydrochloric acid and water; and the silicious matter remaining filtered off and ignited. The latter is fused with a little carbonate of soda, the fusion dissolved in nitric acid and water, and the nitric solution added to the original filtrate, which is again evaporated to dryness. After dissolving in a little hydrochloric acid and water, the silica is removed by filtration. The filtrate is made slightly alkaline with ammonia, and then slightly acidified with nitric acid. The solution, which measures about 100 cc., is heated to 80° C.; 50 cc. of molybdate solution are added, and, after standing for about one minute, the mixture is agitated for five minutes by letting a stream of air or natural gas bubble through it. The yellow precipitate is filtered by the aid of suction and washed with pure water. It is then titrated with standard alkali, the solution being standardized by steels and pig irons in which the phosphorus, has already been determined by the molybdate-magnesia method, according to Blair's "Analysis of Iron," (last edition.)

Solutions.—The molybdate solution is made by dissolving 1 lb. of molybdic acid in 1200 cc. of strong ammonia, and 800 cc. water, and pouring this solution into 6000 cc. of nitric acid (sp. gr. 1.2).

DETERMINATION OF MANGANESE IN ORES.

From 3 to 5 grains of ore are dissolved in strong hydrochloric acid, and the solution evaporated to dryness. The dry mass is redissolved in hydrochloric acid and water, and the

insoluble residue filtered off and ignited. The residue is fused with carbonate of soda, and the fusion dissolved in hydrochloric acid and water. The solution, after separating the silica, is added to the main solution; potassium chlorate is then added, care being taken to expel the chlorine generated in excess. The iron is precipitated as basic acetate, the precipitate being redissolved and reprecipitated twice. For each gram of ore 2 grams of ammonium acetate are used. The combined filtrates are then concentrated and the manganese precipitated by bromine as binoxide. The precipitate is filtered off and dissolved in hydrochloric acid, the solution neutralized with ammonia, and the manganese again precipitated as ammonium manganese phosphate, according to Blair. Ignite and weigh as manganese pyro-phosphate. When the percentage of manganese is less than .5, the binoxide of manganese is converted for weighing into protosesquioxide.

DETERMINATION OF SILICON IN PIG IRON.

Dissolve 1 gram of borings in 35 cc. of "silicon mixture," and evaporate until the formation of fumes of sulphuric anhydride begins. When sufficiently cool, dissolve in a little water and about 10 cc. of strong hydrochloric acid. Filter, using suction, wash with hot water and dilute hydrochloric acid (1.1 sp. gr.) ignite, and weigh as silica.

Solutions.—The "silicon mixture" is made by adding 100 cc. of strong sulphuric acid to 900 cc. of nitric acid, (1.20 sp. gr.)

DETERMINATION OF SULPHUR IN PIG IRON.

Weigh out into a 500 cc. flask, 5 grams of drillings, add 50 cc. of water, and, after connecting the flask with the absorption apparatus, add 50 cc. of strong hydrochloric acid. Without delay light a small flame under the flask, and dissolve as rapidly as desired. The evolved gas bubbles through 50 cc. of ammoniacal cadmium chloride solution contained in a 7-in. foot test-tube. When the drillings have dissolved, boil the solution to expel the last traces of sulphuretted hydrogen from the flask. Rinse out the contents of the test-tube into a

shallow porcelain dish, made slightly acid with hydrochloric acid, add starch solution, and titrate to a decided blue color with a standard iodine solution.

Solutions.—Ammoniacal cadmium chloride solution is made by dissolving 30 grams of cadmium chloride in 5000 cc. of water and 1000 cc. of strong ammonia. The iodine solution is prepared by dissolving 8.5 grams of iodine and about 25 grams of potassium iodide in a small quantity of water, and diluting to 2000 cc. This solution is then exactly standardized by a standard steel (rather high in sulphur) in which the percentage of sulphur has been exactly determined by the aqua regia method, as described by Blair in the last edition of his "Chemical Analysis of Iron." Except only in a very few cases, all pig irons are tested for sulphur by the evolution method.

DETERMINATION OF PHOSPHORUS IN PIG IRON.

Dissolve 3 grams of the sample in a 50 cc. of nitric acid (1.20 sp. gr.), evaporate to dryness, and heat the residue over a bare flame for five minutes. Cool, dissolve in a few cc. of strong hydrochloric acid, and evaporate until the solution measures about 10 cc. Then add about 20 cc. of strong nitric acid, and boil for about four minutes. Dilute with water and filter. The solution should have a volume of about 75 cc. Complete the determination as in the case of ores.

For the sake of rapidity we use the following method for several grades of Bessemer pig iron :—Dissolve 3 grams of the metal in 100 cc. of nitric acid (1.13 sp. gr.) When the borings have completely dissolved add a saturated solution of permanganate of potassium till a decided precipitate remains. Boil three minutes and then add 10 cc. of strong hydrochloric acid. Filter off the carbonaceous residue and proceed further as described for ores.

DETERMINATION OF MANGANESE IN PIG IRON.

Dissolve 3 to 5 grams of the sample in 50 cc. of nitric acid (sp. gr. 1.20), evaporate to dryness and ignite for 5 min-

utes. Cool, redissolve in a few cc. of hydrochloric acid, evaporate an excess of acid and filter. Make the basic acetate separation, etc., as described under Iron Ores.

The color method is also used largely for pig irons, viz: Dissolve .5 gram of pig iron in 15 cc. of nitric acid (sp. gr. 1.20) in an 8-inch test-tube, filter and dilute the filtrate to 50 cc. Draw off 10 cc. with a pipette and place the solution in an 8-inch test-tube. Add 3 cc. of nitric acid (sp. gr. 1.20). Heat to boiling, add about .2 grams of lead peroxide, and boil the mixture for 2 minutes. Add about 15 cc. of cold water, and allow the tube to stand in cold water till the lead peroxide settles completely. Compare the color of the sample for analysis with that of a standard pig iron treated similarly. Standards are always made by the basic acetate method, the manganese being weighed as pyrophosphate.

DETERMINATION OF SULPHUR IN STEEL.

See Pig Iron.

DETERMINATION OF PHOSPHORUS IN STEEL.

See Pig Iron.

The permanganate oxidation method is generally used; the filtering off of silica becomes unnecessary in this case.

DETERMINATION OF CARBON IN STEEL.

Dissolve 3 grams of steel in 200 cc. of a saturated solution of cupric potassium chloride, containing 10 cc. of strong hydrochloric acid, at 60° C, with constant stirring.

Filter off the carbon aceous residue on an asbestos plug, and wash with dilute hydrochloric acid and hot water.

Transfer the residue to a 500 cc. flask and burn with a mixture of chromic and sulphuric acids, absorbing for weighing the carbonic acid gas evolved.

The combustion train is as follows:

1.—A 500 cc. combustion flask.

2.—An empty tube.

3.—A tube containing :—

.2 grams of pyrogallic acid.
5 grams of potassium oxalate.
3 grams of sodium chloride.
.2 grams of sulphuric acid and water necessary to make the volume 20 cc.

4.—A tube containing silver sulphate and strong sulphuric acid.

5.—A tube containing sulphuric acid.

6.—An empty tube.

7.—Geissler potash bulbs containing caustic potash (sp. gr. 1.27); and a guard U-tube containing strong sulphuric acid.

After the combustion, pure air is aspirated through the apparatus for 20 minutes.

Blanks are made, and the apparatus frequently checked by steels of known carbon content. The various minute details are carried out about as given in Blair's work above quoted.

DETERMINATION OF MANGANESE IN STEEL.

See Pig Iron.

The silica filtration is not generally necessary, however.

DETERMINATION OF NICKEL IN STEEL.

Make the basic acetate separation, using 1 gram of steel, and to the filtrate add 10 grams of ammonium acetate and 6 drops of acetic acid. Precipitate with hydrogen sulphide, filter, burn and weigh as Ni O (and Cu O, should copper be present).

Dissolve the ignited precipitate in hydrochloric acid, and a few drops of nitric acid, dilute with water and precipitate any copper in the solution with hydrogen sulphide.

Burn and weigh as Cu O ; subtract the weight from the first weight. The difference represents the quantity of NiO derived from the sample.